LUKENS IRON & STEEL CO.

Frank J. 8/-

1906

Frank J. Sepas - 1906

THE FIRST TO MAKE BOILER PLATES IN AMERICA

LUKENS
IRON AND STEEL COMPANY

Main Office and Works, Coatesville, Pa.

ESTABLISHED 1810 INCORPORATED 1890

A. F. HUSTON, ... PRESIDENT
C. L. HUSTON, . . . VICE-PRESIDENT
JOS. HUMPTON, . . SEC'Y AND TREAS.

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PREFACE

IN presenting the third edition of our handbook, we call attention to the fact that it has been our aim to make it thoroughly practical and a valuable aid to boilermakers and all users of Steel Plate.

Since issuing the last edition the contents have been carefully revised and much new data added to cover changes and improvements made at the mill during late years. Other useful information has been compiled and collected from well-known authorities, and we wish to thank our many friends who so generously assisted us in the work.

LUKENS IRON AND STEEL COMPANY

COATESVILLE, PA.

PAST —— 1810

THE LUKENS IRON AND STEEL COMPANY

THE FIRST TO MAKE BOILER PLATES IN AMERICA

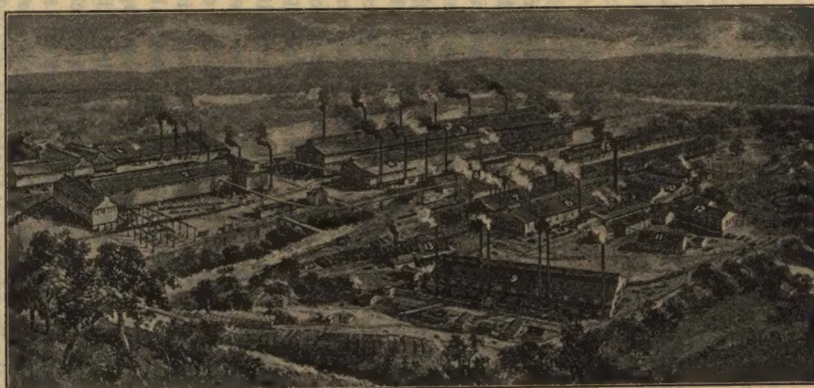
THE OLD MILL

COATESVILLE, PA.

PRESENT —— 1905

WORKS OF THE LUKENS IRON AND STEEL COMPANY

COATESVILLE, PA.



1. 140 inch Plate Mill.
2. 48 inch Universal Mill.
3. No. 2 Open Hearth Steel Plant.
4. 34 inch Slabbing Mill.
5. Slabbing Mill Boiler House.
6. 22 inch Puddle Mill.
7. 84 inch Plate Mill.
8. 134 inch Plate Mill.
9. No. 1 Open Hearth Steel Plant.
10. Machine Flanging Shop.
11. Machine Shop.
12. Structural Shop.
13. Gas Producers for East Side.

RETROSPECTIVE

THE FIRST TO MAKE BOILER PLATES IN AMERICA

In presenting this brief history of our origin and development, we wish to inform our friends, who have been interested in our historical as well as long and successful business career, that whilst we have been advertised, and are widely known as having been established in 1810, the actual and original establishment of our works dates back to the year 1790, when Isaac Pennock, the great-grandfather of the present management, built a mill and began the manufacture of Iron at a place now called Rokeby, situated on Buck Run, Chester Co., Pa., about four miles south of Coatesville. He was signally successful in this pioneer industry, notwithstanding he had been raised as a farmer; his parents strongly objected to his venturing into a business with which he was entirely unfamiliar, as they felt he would be squandering his money in a hopeless undertaking. The mill he first built was called the "Federal Slitting Mill," charcoal slabs being heated in an open charcoal fire, rolled out into plates, and then slit up into rods for general blacksmith use. In 1810 he bought a saw-mill property on the Brandywine at Coatesville, which he converted into an Iron Mill. The mill at that time was called "Brandywine." It was, therefore, in the year 1810 that

the Old Mill was located on the site, which has since developed into the large plant at present in operation, covering many acres of ground, and giving steady employment to a large number of men.

In 1816, Dr. Charles Lukens, a son-in-law of Isaac Pennock, and maternal grandfather of the present management, came into possession of the property, and carried on the business of Iron making until his death in 1825. It was between these dates that the first Boiler Plates produced in this country were made in this mill by Dr. Lukens.

Dr. Lukens died at an early age, and in accordance with his special request, was succeeded by his widow, Rebecca W. Lukens, who continued to successfully carry on the business, although severely handicapped by the fact that in those days there were no railroads. The finished material had to be teamed to Philadelphia, a distance of 38 miles, or to Wilmington, 26 miles, while the coal used was hauled from Columbia, about 42 miles away. However, in spite of these difficulties, she carried on the Iron making business with the assistance of a superintendent to look after the works and employees, while she herself assumed full control and management of the commercial part. Mrs. Lukens was considered an extraordinary business woman, and she built up a business which has remained in the family for four generations, having been continuously successful up to the present time. It was in their honor that the name of the works was changed from "Brandywine" to "Lukens."

After Mrs. Lukens' death the business was conducted by her sons-in-law, Abram Gibbons and Dr. Charles Huston. Mr. Gibbons retired in 1855, after an honorable and prosperous, although short, business career, leaving the works in Dr. Huston's hands, who, with his partner, Mr. Charles Penrose, carried on the manufacture of Iron up to the time of Mr. Penrose's death in 1881,—they having

been joined by Dr. Huston's two sons, A. F. and C. L. Huston, upon their graduation from college in 1872 and 1875, respectively. Dr. Huston remained the head of the concern until his death in January, 1897. A history of the business would not be complete without a fuller reference to Dr. Huston's life and the close connection he had with the development of the Iron and Steel industry of the country. He was born in Philadelphia in 1822, graduated at the University of Pennsylvania in 1840, finished a three years' course in medicine at the Jefferson Medical College in 1843, which was supplemented by eighteen months of special study in Europe. He began the practice of his profession in Philadelphia, married Miss Isabella Pennock Lukens of Coatesville, and settled down to the life of a doctor. In 1849 they moved to the country. He entered the Iron business in 1850, and for nearly fifty years was actively engaged in it. In 1875, when the United States Government began requiring that plates used in the construction of Steamboat Boilers should be stamped with their Tensile Strength, Dr. Huston promptly purchased a testing machine, and began investigating the properties of Iron and Steel. In 1877, when the manufacturers of Boiler Plate were requested by the Treasury Department to send a committee to Washington to advise with the Board of Supervising Steamboat Inspectors in framing a proper standard of tests, Dr. Huston was chosen Chairman of that Committee, and with his practical knowledge of the character of metal, and his experience in testing, his recommendations were adopted by the Board of Inspectors, and in addition his counsel was frequently sought by the Government. His recommendations were sought and followed by the leading Steam Boiler Inspection and Insurance Companies of this country, also by the Committee appointed by the City Councils of Philadelphia, in establishing their standard of test requirements for high-grade

Boiler Plates. In 1878–79 he published Revised Articles in the *Journal* of the Franklin Institute, upon the behavior of Iron and Steel under varying conditions of heat and stress. These articles attracted the notice of engineers abroad years afterward, they having just taken up that class of investigation. Later, in 1895, Dr. Huston was selected by the Hon. Chauncey M. Depew as the man best fitted by ability and experience to write the article on the Iron and Steel industry, for his able and comprehensive history of "One Hundred Years of American Commerce." Dr. Huston's scientific education, natural ability, and high personal character have permeated all departments of the Lukens Works.

Originally the plates were made from single charcoal blooms; the blooms being made in the old-fashioned forge fire, then reheated over an ordinary grate fire, and rolled into plates, or sheets. The plates were shipped without being sheared; the shearings in those days were cut into nails. Afterward a reverberatory heating furnace was introduced, enabling the scrap to be worked up. The plate rolls of that time, as near as known, were about 16 to 18 inches in diameter, and from 3 to 4 feet long between the housings, being driven by an overshot water wheel. It is said that many times when it looked as if the mill would stall, the workmen would rush for the water wheel, climb up on its rim, and by their united weight help the "pass" through the rolls, thus preventing a "sticker," which invariably meant fire-cracked rolls and, later on, broken ones. Owing to the constant increase of business, which necessitated more power, the overshot water wheel was afterward supplemented by a breast wheel, so geared that it would convey more power to the rolls, and, in addition, a heavy fly-wheel was introduced, geared to a high speed for storage of power. This permitted the use of larger rolls, which were then changed to 21 inches in diameter and 66 inches long. The mill

was operated in this shape until 1870, when a modern steam Plate Mill was erected near-by, with chilled rolls 25 inches by 84 inches,—the old mill being afterward used as a Puddling Mill to prepare stock for the new modern mill. After several more changes, each time the rolls being made larger to meet the increased demand for wider and longer Plates, there was finally placed in position a Three-high Mill, with chilled rolls 34 inches in diameter by 120 inches long, weighing 18 tons each. This was then the largest mill of its kind ever erected in the United States. This large mill, driven by a large Corliss Engine, was equipped with automatic hydraulic lifting tables and modern cooling tables with mechanical transferring apparatus for conducting the plates to the hydraulic and steam shears. Other improvements were added from time to time, including a set of straightening rolls placed so as to take the plates as they come from the mill while still hot, and transform a wavy and irregular surface into a level and true one.

In 1899 a 48-inch Universal Mill was added, which makes plates with rolled edges from 8 inches wide up to 48 inches wide and with lengths up to over 100 feet. In the same year a new Open Hearth Steel Plant was built, adding six 50-ton furnaces and more than doubling the capacity for producing steel. Three years later a massive Slabbing Mill was installed, second to none in the country, either in size or design. The aim has been always to keep fully up to the times in all respects, thus following the policy of the late President, Dr. Charles Huston, who frequently repeated the remark that it was better to be ahead of the times than one whit behind. In the summer of 1903 still another mill was put in operation, larger than any of its predecessors, with rolls 140 inches long and capable of rolling plates up to 136 inches wide. This mill was equipped with the latest and most approved ideas, with a capacity of output second to no mill in

existence. A run from this mill was made of 413 tons of finished plates rolled and sheared complete in 11½ hours, which can be considerably exceeded now. This mill is equipped with three mammoth continuous furnaces of horizontal type, and two pit furnaces, each with four pits. Electric traveling cranes handle the raw and finished product, and two mammoth hydraulic shears, with a capacity for shearing plates 2¼ inches thick, in addition to four large steam shears, complete the equipment.

The 120-inch Plate Mill was enlarged some years ago to 134 inches, but during 1904 was reduced in length of rolls to 112 inches, keeping the diameter 36 inches, as before; thus making an exceptionally stiff mill, capable of rolling plates up to 108 inches wide as thin as possible. It is now rolling plates of 108 inches width down to $\frac{3}{16}$ inch and thinner, also 96 inches width down to ⅛ inch and thinner. These are rolled too with very uniform thickness throughout. At present no other mill in existence, so far as known, can approximate such rolling.

All the finishing mills, embracing the 140-inch, 112-inch, and 84-inch Sheared Plate Mills, and the 48-inch Universal Plate Mill, are equipped with straightening rolls to flatten the rolled plates as soon as they leave the mills, while still red hot, thus making the finished product as perfect as possible.

The present property of the Lukens Iron and Steel Company covers an area of over two hundred acres, upon which stand twelve great buildings—a 140-inch plate mill, a 48-inch universal mill, two open-hearth steel plants containing six furnaces each, a 34-inch slabbing mill, a large boiler house, a 22-inch puddle mill, an 84-inch plate mill, a 112-inch plate mill, a machine flanging shop, a machine shop, a structural shop, and a roll-turning shop. Here also are the gas producers for the east side. The product of the works includes all sorts of boiler and flat structural steel for building pur-

poses, for bridges, ships, etc., and flanged work, much of which is covered by the Company's own patents, and all in demand in every part of the United States and wherever American commerce extends. The works are at the basis of the commercial life of Coatesville, employing an army of sixteen hundred operatives.

To the large property of the Lukens Iron and Steel Company was more recently added a beautiful adornment, an office building built of brick in the old colonial style of architecture. The building is practically fireproof, with steel floor girders carrying fifteen inches of concrete upon which rests the floor proper. Both gas and electricity are used for illuminating the latter provided by the company's own plant, and the heating is the vapor system regulated by a thermostat system, which maintains a uniform temperature. The first floor is occupied by the treasurer, auditor, purchasing agent and their assistants, and also contains a telephone exchange whence connection may be had, not only with all the departments of the works, but with the entire country by the long distance lines. On the second floor are the rooms of the president, vice-president, and the general sales agent. The basement contains a department of comfort equal in all respects to a first-class hotel. The edifice occupies the center of a handsome lawn, and is considered a model in its way.

INDEX

OUR PRODUCT

Including

SHEARED AND UNIVERSAL

STEEL PLATES

FLANGED AND DISHED HEADS, MANHEADS AND BOILER BRACES

Also

INGOTS	BILLETS
BLOOMS	SLABS

SIZES OF SHEARED PLATES AND HEADS

ROLLED BY

LUKENS IRON AND STEEL COMPANY

Thickness.	WIDTHS AND LENGTHS																Dia. of Heads.
	132	126	120	114	108	102	96	90	84	78	72	66	60	48	36	24	
10							168	180	192	192	200	200	200	200	200	200	102
8						180	192	200	210	220	240	250	260	270	270	270	108
3/16					180	192	200	210	220	240	250	260	270	300	300	300	108
1/4			160	180	210	240	270	300	330	360	360	390	390	390	390	360	126
5/16		180	240	270	300	330	360	420	420	450	480	480	480	480	420	360	132
3/8	180	240	270	300	330	360	390	450	450	480	540	540	540	540	420	360	136
7/16	192	270	300	330	360	390	420	450	480	510	570	600	600	600	420	360	136
1/2	210	270	312	360	390	420	450	480	510	540	600	600	600	600	420	360	136
9/16	240	270	312	360	420	450	480	480	510	570	600	600	600	600	420	360	136
5/8	240	300	348	390	450	480	510	510	540	600	600	600	600	600	420	360	136
11/16	240	300	360	420	450	450	480	510	540	600	600	600	600	600	420	360	136
3/4	240	300	360	390	420	450	450	480	510	540	570	600	600	600	420	360	136
7/8	240	300	330	360	390	420	420	450	490	510	540	570	600	600	420	360	136
1	240	270	300	330	360	390	390	420	450	480	510	540	570	600	420	360	136
1 1/8	240	270	300	300	330	360	390	390	420	450	480	510	540	600	420	360	134
1 1/4	228	240	270	270	300	330	360	390	390	420	450	480	510	570	420	360	134
1 3/8	210	228	240	252	270	300	330	360	360	390	420	450	480	540	420	360	132
1 1/2	192	210	228	240	252	270	300	330	330	360	390	420	450	510	420	360	132
1 3/4	180	192	204	216	228	240	270	288	300	330	360	390	420	480	390	360	132
2	162	180	192	204	216	228	240	252	270	300	330	360	390	450	390	360	132

Plates of greater dimensions than shown in above table may be submitted for special consideration.

Universal Mill Steel Plates

Our Universal Plates are rolled on a Three-High Mill, and while still hot are passed through straightening rolls and edges straightened with Electric Power straightener. The finish on the edge of all our U. M. Plates is smooth and true.

We roll ¼ inch thick and over, 9 inches to 36 inches wide, 100 feet long, or up to 46 inches wide, 75 feet long.

UNIVERSAL MILL PLATES

LENGTHS IN INCHES

Thickness	WIDTH IN INCHES							
	46-43	42-38	37-33	32-28	27 23	22-18	17-13	12-9
$\frac{1}{4}$	420	420	420	480	600	720	900	900
$\frac{5}{16}$	480	600	600	720	720	900	900	900
$\frac{3}{8}$	900	900	960	1080	1200	1200	1200	1200
$\frac{7}{16}$	900	900	1080	1080	1200	1200	1200	1200
$\frac{1}{2}$	900	1080	1080	1080	1200	1200	1200	1200
$\frac{9}{16}$	900	1080	1080	1080	1200	1200	1200	1080
$\frac{5}{8}$	960	960	960	1020	1080	1080	1200	1080
$\frac{3}{4}$	800	840	840	840	960	1080	1080	840
$\frac{7}{8}$	600	600	660	780	840	900	900	840
1	480	540	600	650	720	780	780	720
$1\frac{1}{8}$	480	540	540	600	650	700	700	650
$1\frac{1}{4}$	480	540	540	540	600	650	620	540
$1\frac{3}{8}$	420	480	420	480	500	580	570	540
$1\frac{1}{2}$	380	480	420	420	480	500	520	500
$1\frac{5}{8}$	300	400	400	400	420	420	480	420
$1\frac{3}{4}$	300	400	360	360	360	420	420	420
$1\frac{7}{8}$	240	300	300	300	300	300	300	300
2	240	300	300	300	300	300	300	300

Plates of greater dimensions than shown in above table may be submitted for special consideration.

SLABBING MILL

Our Slabbing Mill, second to none in the country and most modern in equipment, is capable of rolling slabs and blooms up to 20,000 lbs., 48 inches wide and 22 inches thick.

Straightening Rolls

We call particular attention to the fact that all our mills, from the 84-inch mill up to the 140-inch mill and including the Universal mill, are equipped with specially constructed plate straightening rolls, so placed as to take plates as they leave the mill rolls, while still red hot, changing a wavy and buckled surface into a flat and level one.

All boiler, bridge, and ship builders will recognize the immense benefit of this, enabling them to turn out a handsome job without first expending extra time and labor in trying to straighten a badly buckled plate, as we do the work while the plates are hot, producing no injurious strains or marred (hammer-marked) surfaces.

Machine-Flanged Boiler Heads and Flue Holes

Having since 1885 been in the business of Flanging by Machinery, Round Boiler Heads and Flue Holes, we feel that our experience and skill, obtained during that time, enables us now to turn out the best character of such work, and far ahead of the majority of such work upon the market to-day. We are prepared to furnish

STEEL BOILER HEADS

ready flanged, of any diameter, 12 inches to 132 inches, outside measurement. We are prepared also to flange **Flue Holes**, from 6 inches to 60 inches or more.

We keep standard sizes of Heads, ready to flange, in stock at our works, thus enabling boiler-makers who have time contracts to get their work out quickly.

Machine-Flanged Heads, when properly done, are better than hand flanged. They are perfectly round and without hammer marks; but, which is the most important, they are heated all over in a furnace and **Flanged at one Heat,** thus relieving them of local strains.

We claim advantages over other Flanging Machines, as follows:

1. **Smooth, Round Flanges.**

2. **Edges Thickened Up,** not drawn out, as is the case in hydraulic flanging.

3. **Radius of Flange Varied** to suit customer and work.

4. **We don't have a hole punched in the center of heads,** as many machines require, to cause trouble to the boiler-makers.

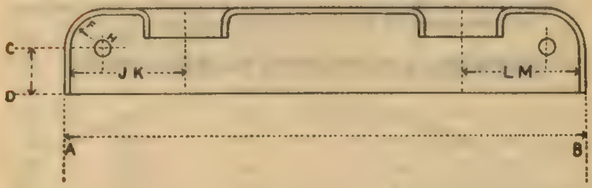
5. Our machines will flange any **Odd** or **Even** sizes wanted, from 12 inches to 132 inches.

6. Our machine-dished Boiler Heads, 12 inches to 126 inches, are the finest and best to be had. We have recently greatly improved our facilities for this work with patented improvements, so that we can turn out especially fine work of any diameter and thickness within the limits of Plate rolling.

DIRECTIONS FOR ORDERING FLANGED WORK

Send a sketch of heads showing the following directions:

FLANGED BOILER HEADS WITH MANHOLES



Thickness of metal..........................inches

Distance A to B is............................ "

" C to D is............................ "

" F to H is............................ "

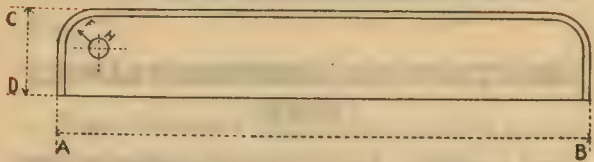
" J to K is............................ "

" L to M is............................ "

Size of Manhole..................... ...... "

State whether one or two Manholes are wanted :... ....

FLANGED BOILER HEADS



Thickness of metal........ ....inches.
Distance A to B is...........................inches.
Distance C to D is...........................inches.
Distance F to H is......... ....inches.

If flue holes are wanted give—

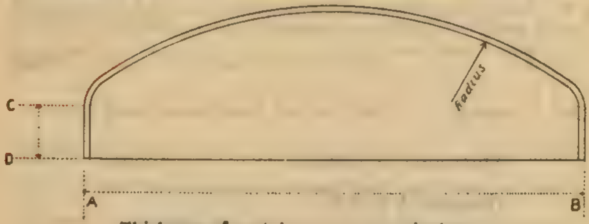
Number of flue holes.

Distance between centres of flue holes.

Distance between centre line of upper row of flue holes and centre line of head.

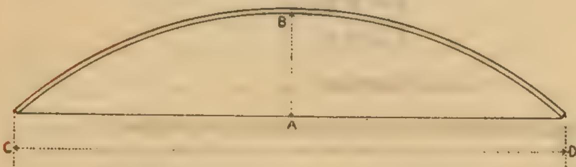
State whether the flue holes are to be flanged the same way as outside flange, or in the opposite direction.

FLANGED AND DISHED BOILER HEADS



Thickness of metal.........................inches.
Distance A to B is...........................inches.
Distance C to D is...........................inches.
Radius of Dish...............................inches.

DISHED HEADS



Thickness of metal.........................inches.
Distance A to B is...........................inches.
Distance C to D is...........................inches.

PRICES FOR FLANGING HEADS

Adopted as standard by Steel Plate Manufacturers, April 4, 1901

Outside Diameter.	3/16" thick	1/4" thick	5/16" and 3/8" thick	7/16" and 1/2" thick	9/16" and 5/8" thick	11/16" and 3/4" thick	13/16" and 7/8" thick	15/16" and 1" thick
12 and under 18 in.	$1.00	$1.00	$1.00	$1.00	$1.00	. . .	. .	. . .
18 " 24 "	1.00	1.00	1.00	1.00	1.00	$1.50	. . .	. . .
24 " 30 "	1.00	1.00	1.00	1.00	1.20	1.80	$2.00	. . .
30 " 36 "	1.20	1.20	1.10	1.20	1.70	2.30	2.70	. . .
36 " 42 "	1.60	1.60	1.40	1.60	2.30	2.90	3.50	$4.20
42 " 48 "	2.00	2.00	1.80	2.00	3.00	3.70	4.40	5.40
48 " 54 "	3.00	2.70	2.40	2.70	3.70	4.70	5.50	6.80
54 " 60 "	4.00	3.50	3.00	3.50	4.40	6.00	6.90	8.50
60 " 66 "	. . .	4.30	3.70	4.30	5.50	7.30	8.40	10.20
66 " 72 "	. . .	5.50	4.50	5.50	6.70	8.60	9.90	11.90
72 " 78 "	. . .	6.80	5.50	6.80	8.00	9.90	11.50	13.70
78 " 84 "	. . .	8.20	6.80	8.20	9.40	11.20	13.20	15.70
84 " 90 "	. . .	10.00	8.30	10.00	11.00	12.50	15.00	18.00
90 " 96 "	. .	12.20	10.10	12.20	14.30	16.50	18.20	20.30
96 " 102 "	. . .	15.50	12.10	15.50	17.60	20.50	22.60	25.50
102 " 108 "	. . .	. . .	15.00	19.00	21.00	25.00	27.00	30.00
108 " 120 "	. . .	. . .	18.00	23.00	26.00	30.00	33.00	36.00
120 " 128 "	. . .	. . .	. . .	27.00	31.00	35.00	39.00	43.00
Total Depth,	2"	3"	4"	4½"	5"	5½"	6"	6½"

Where the total depth, including metal, radius, and straight flange exceeds the normal total depth given above, 10 per cent. to be added to list for each additional ½ inch or fraction thereof.

For flanged heads of larger size will quote price upon application.

PRICES FOR DISHING HEADS

Adopted as standard by Steel Plate Manufacturers, April 4, 1901

OUTSIDE DIAMETER WHEN FLANGED	MAXIMUM DEPTH OF DISH	$\frac{3}{16}$″ and $\frac{1}{4}$″ thick	$\frac{5}{16}$″ and $\frac{3}{8}$″ thick	$\frac{7}{16}$″ and $\frac{1}{2}$″ thick	$\frac{9}{16}$″ and $\frac{5}{8}$″ thick	$\frac{11}{16}$″ and $\frac{3}{4}$″ thick	$\frac{13}{16}$″ and $\frac{7}{8}$″ thick	$\frac{15}{16}$″ and 1″ thick
12 inches	1⅝ inches	$1.30	$1.30	$1.30	. . .	. . .	. . .	. . .
15 "	2 "	1.30	1.30	1.30	. . .	. . .	. . .	. . .
18 "	2⅜ "	1.30	1.30	1.30	$1.30	. . .	. . .	. . .
24 "	3¼ "	1.50	1.30	1.50	1.50	$2.00	. . .	. . .
30 "	4 "	1.80	1.50	1.80	1.90	2.50	$3.00	. . .
36 "	4¾ "	2.30	1.90	2.30	2.50	3 00	4.00	. . .
42 "	5⅝ "	2.80	2.30	2.80	3.10	4.00	5.00	$6.00
48 "	6⅜ "	3.50	2.80	3.50	4.00	5.00	6.00	7.00
54 "	7¼ "	4.50	3.50	4.50	5.00	7.00	8.50	10.00
60 "	8 "	6.50	4.50	6.50	7.00	9.00	11.00	13.00
66 "	8 "	8.50	6.00	8.50	9.00	12.00	14.00	16.00
72 "	9⅝ "	10.50	7.50	10.50	11.00	15.00	17.00	19.00
78 "	9⅝ "	13.00	9.50	13.00	14.00	18.00	20.00	22.00
84 "	11¼ "	15.50	12.00	15.50	17.00	21.00	23.00	25.00
90 "	11 $\frac{3}{16}$ "	18.00	15.00	18.00	20.00	24.00	27.00	30.00
96 "	12⅞ "	22.00	18.00	22.00	24.00	28.00	32.00	36.00
102 "	12¾ "	. . .	22.00	27.00	29.00	33.00	37.00	42.00
108 "	14½ "	. . .	27.00	33.00	34.00	38.00	43.00	48.00

Intermediate and larger sizes and depth of dish varying from above, will be quoted on upon inquiry, but in no case less than the next size greater on list.

These prices do not include flanging, simply Dishing.

PRICES FOR FLANGING FLUE HOLES

Adopted as standard by Steel Plate Manufacturers, April 4, 1901

Inside Diameter	$\frac{5}{16}''$ to $\frac{1}{2}''$ thick	$\frac{9}{16}''$ and $\frac{5}{8}''$ thick	$\frac{11}{16}''$ and $\frac{3}{4}''$ thick	$\frac{13}{16}''$ and $\frac{7}{8}''$ thick	$\frac{15}{16}''$ and 1″ thick
6″	$2.00	$2.50	$4.00	$5.00	$6.00
7″-8″-9″	2.50	3.50	4.50	6.00	7.00
10″-11″-12″	3.00	4.00	5.00	7.00	8.00
13″-14″-15″-16″	3.50	4.50	6.00	8.00	9.00
17″-18″-19″-20″	4.00	5.00	7.00	9.00	11.00
22″-24″	4.50	6.00	8.00	10.00	13.00
26″-28″	5.00	7.00	9.00	12.00	16.00
30″-32″	6.00	8.00	11.00	15.00	19.00
34″-36″	7.00	9.00	13.00	18.00	22.00
38″-40″	8.00	11.00	15.00	21.00	26.00
42″-44″	9.00	13.00	18.00	24.00	30.00
46″-48″	10.00	16.00	21.00	28.00	35.00
50″-52″	12.00	19.00	25.00	33.00	40.00
54″-56″	15.00	22.00	29.00	38.00	45 00
58″-60″	18.00	26.00	33.00	43.00	51.00

Material punched out of centers to be retained by manufacturer.

Sizes other than those shown to be quoted on, but in no case price to be less than price of size immediately above same on list. An extra charge may have to be made in case holes are to be flanged in very heavy plates, which would entail extra expense for handling.

The above list does not apply to collar flanges.

MANHOLES, FITTED COMPLETE

Adopted as standard by Steel Plate Manufacturers, April 4, 1901

In plates less than ¾ inch thick, ...	$10.00
In plates ¾ inch and under ⅞ inch thick,	11.00
In plates ⅞ inch and 1 inch thick, ...	12.00

Sizes

No. 1, .	9 x 14 inches	No. 3, . .	11 x 15 inches
No. 2, .	10½ x 16 "	No. 4, . .	11 x 13 "

In case flanged and faced manhole openings are ordered without fittings, the charge is to be on basis of $6.00 for each in the lighter gauges, with proportionate extra for heavy gauges. In case manhole fittings are ordered without the flanged manhole, $4.00 per set will be charged.

We are prepared to quote for special sizes on application.

SADDLE MANHOLES, COMPLETE

Thickness.	Net Price
⅝ inch, ...	$11.00
11/16 inch to ¾ inch, ...	12.00
13/16 inch to 1 inch, ...	13.00
Over 1 inch not less than	14.00

HAND HOLES, FITTED COMPLETE

In plates less than ¾ in. thick, size 6 x 10 ins., $7.00 each
In plates less than ¾ in. thick, size 4 x 6 ins., 6.00 each

If plates are ¾ inch thick, ...	$1.00 extra.
If plates are ⅞ inch thick, ...	2.00 extra.
If plates are 1 inch thick, ...	3.00 extra.

Prices for Cutting Tube Holes

Diameter of Hole	$\frac{5}{16}''$ and $\frac{3}{8}''$ thick	$\frac{7}{16}''$ and $\frac{1}{2}''$ thick	$\frac{9}{16}''$ and $\frac{5}{8}''$ thick	$\frac{11}{16}''$ and $\frac{3}{4}''$ thick
2 inch, ...	6 cents	$7\frac{1}{2}$ cents	9 cents	$10\frac{1}{2}$ cents
$2\frac{1}{2}$ "	$6\frac{1}{2}$ "	8 "	$9\frac{1}{2}$ "	11 "
3 "	7 "	$8\frac{1}{2}$ "	10 "	$11\frac{1}{2}$ "
$3\frac{1}{2}$ "	$7\frac{1}{2}$ "	9 "	$10\frac{1}{2}$ "	12 "
4 "	8 "	$9\frac{1}{2}$ "	11 "	$12\frac{1}{2}$ "
$4\frac{1}{2}$ "	9 "	$10\frac{1}{2}$ "	12 "	$13\frac{1}{2}$ "
5 "	10 "	12 "	14 "	16 "
6 "	12 "	14 "	16 "	18 "

Above prices are for *drilling*. For *punching* and *reaming* can offer a discount from figures given. The latter makes a strictly first-class job. The strain that may be caused by the operation of punching is relieved by putting the head in a large furnace and annealing it after the operation of punching is completed. This plan is pursued by some of our largest locomotive works.

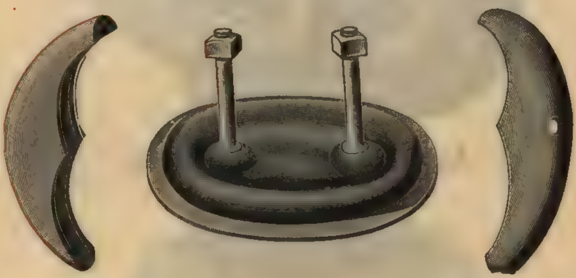
THE LUKENS PRESSED STEEL MANHEAD

Made from best grade **Open Hearth Steel Plate,** equipped with Single Loose Bolt, Ball and Socket Joint and Gasket, showing also Single Bolt, Upset and Riveted in Manhead.

We furnish either style preferred by the user when ordering. No difference in price. They are designed for any steam or air pressure required.

THE LUKENS PRESSED STEEL MANHEAD

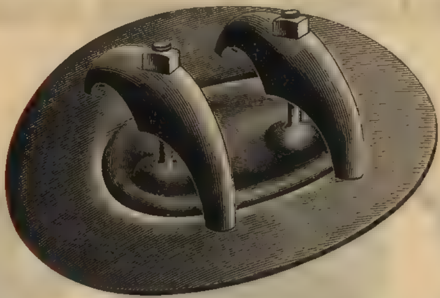
DOUBLE BOLT



Which shows the Manhead equipped with two Riveted Bolts. This style is largely used in Marine work, and owing to the light weight of same, can be placed in position with one hand and readily adjusted. We recommend the double bolt manhead as superior to the single bolt for high pressures; the latter may be used with entire satisfaction, however, for low pressure tanks, etc., where there is no excessive strain.

The Bolts in the Lukens Manheads are so neatly and thoroughly riveted that they are like one solid piece of metal, and from a mechanical standpoint are a thing of artistic beauty.

THE LUKENS MANHOLE SADDLE



As Applied to Shell of Boiler

Can be set to any diameter of Boiler. Price includes complete fittings plus the cost of the metal in Manhole frame, which weighs about 100 lbs. unless made extra thick.

THE LUKENS MANHEAD

As Applied to Dished Head

HUSTON
PATENT BOILER BRACE

Old Style
"Standard"

New Style
"Improved"

HUSTON PATENT BOILER BRACE

In point or quality, strength and lightness in weight, workmanship, general appearance and finish, the Huston Patent Boiler Brace is acknowledged by mechanical experts to be the very best yet produced, and superior to any other brace on the market.

They are carefully made of a superior quality of Open-Hearth Steel, tested at 55,000 to 60,000 pounds tensile strength, and being cut out of a solid plate and pressed into shape at one heat, gives a brace entirely free from welds and one in which there can be no weak point.

In the old-style welded bar-iron brace there is always present an element of uncertainty; at best the strength of a weld is an unknown quantity, and considering the high heat necessary to make the weld, also the great liability of the iron coming in contact with sulphur in the fire, thereby injuring it, it will readily be seen that the bar-iron brace is in every way inferior to the Huston Brace made of pressed steel. Our braces are heated in a furnace entirely separate from the fuel.

Another point in favor of this brace is the fact that a steel brace is fully 25 per cent. stronger and stiffer than an iron one of the same dimensions, therefore giving the rivets a much better chance for resistance, being relieved of the prying-off strain. Then, too, the width of metal at base of rib in foot, along the fillet where straightening-

out strain comes, is 4½ to 5 inches, while nearly all other braces are only 1½ inches to 2 inches wide at this point.

We make these braces in two styles: The Huston "Standard" (old style) and The Huston "Improved" (new style), both shown in illustrations. They can be had in any length and thickness to suit the trade, but ½ inch and $\frac{7}{16}$ inch are usually found amply strong for any use, while ⅜ inch will do in case of smaller boilers and lower pressures.

By request we will furnish the Huston Brace tested to meet United States Government requirements for Marine work; also to comply with requirements of the various Steam Boiler Inspection and Insurance Companies.

Upon application we will furnish detailed report of results of tests and other information concerning the Huston Patent Boiler Braces.

Write for prices.

Average Weights for HUSTON PATENT BRACES, for Varying Thicknesses and Lengths

THICKNESS	24″ long	30″ long	36″ long	42″ long	48″ long	54″ long	60″ long	72″ long	78″ long
⅜ inch	10 lbs.	12 lbs.	13 lbs.	15 lbs.	18 lbs.	20 lbs.	23 lbs.	26 lbs.	. . .
$\frac{7}{16}$ "	12 "	14 "	16 "	19 "	20 "	23 "	26 "	30 "	34 lbs.
½ "	14 "	16 "	18 "	20 "	23 "	26 "	28 "	34 "	40 "

The above are average weights. Longer lengths furnished when wanted.

STANDARD SPECIFICATIONS

FOR

STEEL PLATE

ETC.

STANDARD SPECIFICATIONS

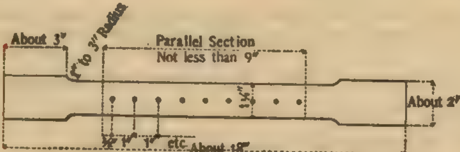
Manufacturers' Standard Specifications governing the Chemical and Physical Properties of Structural and Special Open-Hearth Plate and Rivet Steel, as adopted by The Association of American Steel Manufacturers on August 9, 1895, and revised February 17, October 23, 1896, April 19, 1902, and February 6, 1903.

We trust wherever possible our friends will conform to these specifications. It fills a long-felt want to have uniformity in this direction. It will be noticed that Shell Steel has been dropped entirely, believing that no lower grade than "Flange" should be used in making Boilers.

SPECIAL OPEN-HEARTH PLATE AND RIVET STEEL

1. Testing and Inspection.—All tests and inspections shall be made at the place of manufacture prior to shipment.

2. Test Pieces.—The tensile strength, limit of elasticity and ductility shall be determined from a standard test piece cut from the finished material. The standard shape of the test piece for sheared plates shall be as shown by the following sketch:



Piece to be of same thickness as the plate

On tests cut from other material the test piece may be either the same as for sheared plates, or it may be planed

or turned parallel throughout its entire length, and in all cases where possible, two opposite sides of the test piece shall be the rolled surfaces. The elongation shall be measured on an original length of 8 inches, except as modified in section 12 paragraph *c*. Rivet rounds and small bars shall be tested of full size as rolled.

Four test pieces shall be taken from each melt of finished material, two for tension and two for bending; but in case either test develops flaws, or the tensile test piece breaks outside of the middle third of its gauged length, it may be discarded and another test piece substituted therefor.

3. Annealed Test Pieces.—Material which is to be used without annealing or further treatment shall be tested in the condition in which it comes from the rolls. When material is to be annealed or otherwise treated before use, the specimen representing such material shall be similarly treated before testing.

4. Marking.—Every finished piece of steel shall be stamped with the melt number. Rivet steel may be shipped in bundles securely wired together, with the melt number on a metal tag attached.

5. Finish.—All plates shall be free from injurious surface defects and have a workmanlike finish.

6*a*. Chemical Properties.—Flange or Boiler Steel: Maximum Phosphorus, .06 per cent. Maximum Sulphur, .04 per cent.

6*b*. Extra Soft and Fire Box Steel: Maximum Phosphorus, .04 per cent. Maximum Sulphur, .04 per cent.

7. Physical Properties.—Special Open-hearth Plate and Rivet Steel shall be of three grades: **Extra Soft, Fire Box,** and **Flange** or **Boiler Steel.**

8. Extra Soft Steel.—Ultimate strength, 45,000 to 55,000 pounds per square inch.

Elastic limit, not less than one-half the ultimate strength.

Elongation, 28 per cent.

Cold and Quench bends, 180 degrees flat on itself, without fracture on outside of bent portion.

9. Fire Box Steel.—Ultimate strength, 52,000 to 62,000 pounds per square inch.

Elastic limit, not less than one-half the ultimate strength.

Elongation, 26 per cent.

Cold and Quench bends, 180 degrees flat on itself, without fracture on outside of bent portion.

10. Flange or Boiler Steel.—Ultimate strength, 55,000 to 65,000 pounds per square inch.

Elastic limit, not less than one-half the ultimate strength.

Elongation, 25 per cent.

Cold and Quench bends, 180 degrees flat on itself, without fracture on outside of bent portion.

11. Boiler Rivet Steel.—Steel for Boiler Rivets shall be made of the extra soft grade specified in paragraph No. 8.

12. Modifications in Elongation for Thin and Thick Material.—For material less than $\frac{5}{16}$ inch, and more than ¾ inch in thickness, the following modifications shall be made in the requirements for elongation :

a. For each increase of ⅛ inch in thickness above ¾ inch, a deduction of 1 per cent. shall be made from the specified elongation.

b. For each decrease of $\frac{1}{16}$ inch in thickness below $\frac{5}{16}$ inch, a deduction of 2½ per cent. shall be made from the specified elongation.

c. In rounds of ⅝ inch or less in diameter, the elongation shall be measured in a length equal to eight times the diameter of section tested.

13. Variation in Weight.—The variation in cross-section or weight of more than 2½ per cent. from that specified will be sufficient cause for rejection, except in the case of sheared plates, which will be covered by the following permissible variations :

a. Plates 12½ pounds per square foot or heavier, up to 100 inches wide, when ordered to weight, shall not average more than 2½ per cent. variation above or 2½ per cent. below the theoretical weight. When 100 inches wide and over, 5 per cent. above or 5 per cent. below the theoretical weight.

b. Plates under 12½ pounds per square foot, when ordered to weight, shall not average a greater variation than the following :

Up to 75 inches wide, 2½ per cent. above or 2½ per cent. below the theoretical weight ; 75 inches wide up to 100 inches wide, 5 per cent. above or 3 per cent. below the theoretical weight. When 100 inches wide and over, 10 per cent. above or 3 per cent. below the theoretical weight.

c. For all plates ordered to gauge there will be permitted an average excess of weight over that corresponding to the dimensions on the order equal in amount to that specified in the following table :

Table of Allowances for Overweight for Rectangular Plates when Ordered to Gauge

Plates will be considered up to gauge if measuring not over $\frac{1}{100}$ inch less than the ordered gauge.

The weight of 1 cubic inch of rolled steel is assumed to be 0.2833 lb.

Plates 1/4 Inch and Over in Thickness

Thickness of Plate	Width of Plate			
	Up to 75 in.	75 in. to 100 in.	Over 100 to 115 in.	Over 115 in.
Inch	Per Cent.	Per Cent.	Per Cent.	Per Cent.
$\frac{1}{4}$	10	14	18	. . . .
$\frac{5}{16}$	8	12	16	. . . .
$\frac{3}{8}$	7	10	13	17
$\frac{7}{16}$	6	8	10	13
$\frac{1}{2}$	5	7	9	12
$\frac{9}{16}$	$4\frac{1}{2}$	$6\frac{1}{2}$	$8\frac{1}{2}$	11
$\frac{5}{8}$	4	6	8	10
Over $\frac{5}{8}$	$3\frac{1}{2}$	5	$6\frac{1}{2}$	9

Plates Under 1/4 Inch in Thickness

Thickness of Plate	Width of Plate		
	Up to 50 in.	50 in. to 70 in.	Over 70 in.
Inch	Per Cent.	Per Cent.	Per Cent.
$\frac{1}{8}$ up to $\frac{5}{32}$	10	15	20
$\frac{5}{32}$ " $\frac{3}{16}$	$8\frac{1}{2}$	$12\frac{1}{2}$	17
$\frac{3}{16}$ " $\frac{1}{4}$	7	10	15

STRUCTURAL CAST IRON

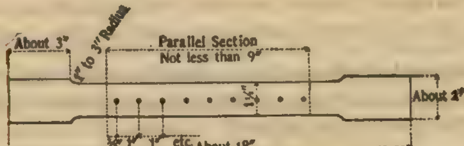
1. Except when chilled iron is specified, all castings shall be tough gray iron, free from injurious cold-shuts or blow-holes, true to pattern, and of a workmanlike finish. Sample pieces one inch square, cast from the same heat of metal in sand moulds, shall be capable of sustaining on a clear span of 4 feet 8 inches, a central load of 500 pounds when tested in the rough bar.

STRUCTURAL STEEL

1. Process of Manufacture.—Steel may be made by either the Open-hearth or Bessemer process.

2. Testing and Inspection.—All tests and inspections shall be made at the place of manufacture prior to shipment.

3. Test Pieces.—The tensile strength, limit of elasticity and ductility, shall be determined from a standard test piece cut from the finished material. The standard shape of the test piece for sheared plates shall be as shown by the following sketch :



Piece to be of same thickness as the plate

On tests cut from other material the test piece may be either the same as for sheared plates, or it may be planed or turned parallel throughout its entire length, and in all

cases where possible, two opposite sides of the test piece shall be the rolled surfaces. The elongation shall be measured on an original length of 8 inches, except as modified in section 12 paragraph *c*. Rivet rounds and small bars shall be tested of full size as rolled.

Two test pieces shall be taken from each melt or blow of finished material, one for tension and one for bending; but in case either test develops flaws, or the tensile test piece breaks outside of the middle third of its gauged length, it may be discarded and another test piece substituted therefor.

4. Annealed Test Pieces.—Material which is to be used without annealing or further treatment shall be tested in the condition in which it comes from the rolls. When material is to be annealed or otherwise treated before use, the specimen representing such material shall be similarly treated before testing.

5. Marking.—Every finished piece of steel shall be stamped with the blow or melt number, and steel for pins shall have the blow or melt number stamped on the ends. Rivet and lacing steel, and small pieces for pin plates and stiffeners, may be shipped in bundles securely wired together, with the blow or melt number on a metal tag attached.

6. Finish.—Finished bars shall be free from injurious seams, flaws or cracks, and have a workmanlike finish.

7*a*. Chemical Properties.—Steel for Buildings, Train Sheds, Highway Bridges, and similar structures: Maximum Phosphorus, .10 per cent.

7*b*. Steel for Railway Bridges: Maximum Phosphorus, .08 per cent.

8. Physical Properties.—Structural Steel shall be of three grades: **Rivet, Railway Bridge,** and **Medium.**

9. Rivet Steel.—Ultimate strength, 48,000 to 58,000 pounds per square inch.

Elastic limit, not less than one-half the ultimate strength.

Percentage of elongation, $\frac{1,400,000}{\text{ultimate strength}}$.

Bending test, 180 degrees flat on itself, without fracture on outside of bent portion.

10. Steel for Railway Bridges.—Ultimate strength, 55,000 to 65,000 pounds per square inch.

Elastic limit, not less than one-half the ultimate strength.

Percentage of elongation, $\frac{1,400,000}{\text{ultimate strength}}$.

Bending test, 180 degrees to a diameter equal to thickness of piece tested, without fracture on outside of bent portion.

11. Medium Steel.—Ultimate strength, 60,000 to 70,000 pounds per square inch.

Elastic limit, not less than one-half the ultimate strength.

Percentage of elongation, $\frac{1,400,000}{\text{ultimate strength}}$.

Bending test, 180 degrees to a diameter equal to thickness of piece tested, without fracture on outside of bent portion.

12. Modifications in Elongation for Thin and Thick Material.—For material less than $\frac{5}{16}$ inch, and more than $\frac{3}{4}$ inch in thickness, the following modifications shall be made in the requirements for elongation :

a. For each increase of $\frac{1}{8}$ inch in thickness above $\frac{3}{4}$ inch, a deduction of 1 per cent. shall be made from the specified elongation, except that the minimum elongation shall be 20 per cent. for eye-bar material and 18 per cent. for other structural material.

b. For each decrease of $\frac{1}{16}$ inch in thickness below $\frac{5}{16}$ inch, a deduction of 2½ per cent. shall be made from the specified elongation.

c. In rounds of ⅝ inch or less in diameter, the elongation shall be measured in a length equal to eight times the diameter of section tested.

d. For pins made from any of the before-mentioned grades of steel, the required elongation shall be 5 per cent. less than that specified for each grade, as determined on a test piece, the center of which shall be one inch from the surface of the bar.

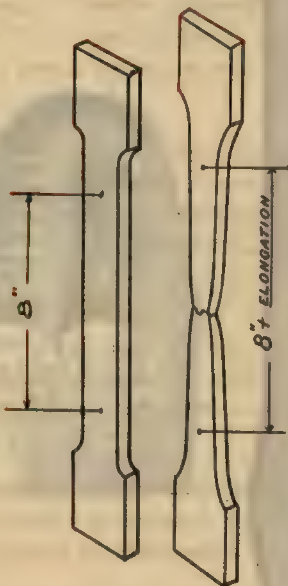
13. Variation in Weight.—The variation in cross-section or weight of more than 2½ per cent. from that specified will be sufficient cause for rejection, except in the case of sheared plates, which will be covered by the following permissible variations:

a. Plates 12½ pounds per square foot or heavier, up to 100 inches wide, when ordered to weight, shall not average more than 2½ per cent. variation above or 2½ per cent. below the theoretical weight. When 100 inches wide and over, 5 per cent. above or 5 per cent. below the theoretical weight.

b. Plates under 12½ pounds per square foot, when ordered to weight, shall not average a greater variation than the following:

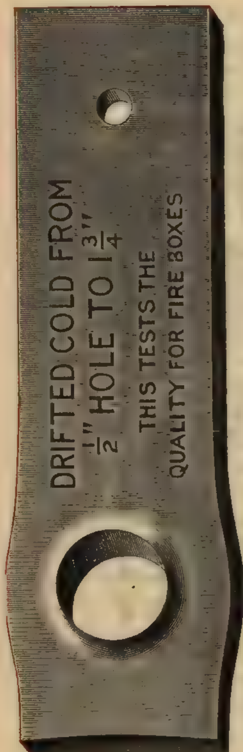
Up to 75 inches wide, 2½ per cent. above or 2½ per cent. below the theoretical weight; 75 inches wide up to 100 inches wide, 5 per cent. above or 3 per cent. below the theoretical weight. When 100 inches wide and over, 10 per cent. above or 3 per cent. below the theoretical weight.

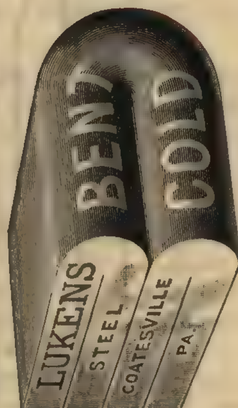
c. For all plates ordered to gauge there will be permitted an average excess of weight over that corresponding to the dimensions on the order equal in amount to that specified in table on page 44.



TEST PIECE BEFORE AND AFTER PULLING

SHOWING REDUCTION OF AREA AND ELONGATION





The accompanying Cuts show the Drifting and Bending Tests

WITHOUT HEATING

EXPLANATION

The term "**Tensile Strength**" or "**Ultimate Strength,**" as usually applied, means the maximum number of pounds per square inch of section required to pull apart a specimen.

"**Elastic Limit,**" of recent time much more accurately termed "**yield point,**" means the point where the applied strain begins to produce a permanent elongation; up to that point the metal will yield slightly, but when the load is removed, will return to its original length like India rubber. It is never safe to strain any structure beyond this point, in actual use, and many prominent engineers rate the strength of metals according to elastic limit instead of tensile strength, not specifying the latter at all.

"**Elongation**" means the percentage of stretch or elongation from a given length, which is now almost universally taken in 8 inches, except for special tests.

"**Reduction of Area**" means the percentage of reduction from the original section area of sample, where it is drawn down in the action of pulling apart. Both "Elongation" and "Reduction of Area" are indications of ductility, or "molasses candy" nature of the steel. Some steel will show a high elongation, but not a high

reduction of area. Some, again, will show a high reduction of area at point of fracture, but a poor elongation. The best steel is that which shows both high elongation and high reduction of area. Tests taken transversely of the same plate will usually show about as high percentage of elongation, but decidedly less reduction of area, than tests taken in the direction in which the plate was rolled.

BRANDS

	Tensile Strength
EXTRA SOFT STEEL,	45000 to 55000
EXTRA LOCOMOTIVE FIRE BOX STEEL,	50000 to 60000
FIRE BOX STEEL,	52000 to 62000
MARINE STEEL,	50000 to 65000
FLANGE STEEL,	50000 to 65000

STEEL FOR BOILERS AND FIRE BOXES

The quality and properties of Structural Steel are always carefully studied by engineers in bridge and ship-building; parts subject to compression, tension, torsion, flexure, etc., being made from material especially made or selected for their particular requirements, and a boiler should be made from still more carefully selected material.

We use exclusively the Siemens-Martin (open hearth) process for making all our grades of boiler plates, and with our finely-equipped Steel Plant, mixing and refining the metal, under the most careful and intelligent management, added to our long years of experience, we are able to carry out our constant aim of being second to none in the superiority of our product.

The Tensile Strength by itself is by no means a safe guide to indicate the value or quality of the steel, and even tensile strength and ductility combined are not conclusive proof of good steel, as so many other elements enter in, to affect the quality. The Tensile Strength may be varied at will by the maker, from very soft to hard, in any of the grades, and without much difference in the expense, simply by the amount of the carbon allowed to remain in the steel. The difference in the expense comes in, in the character of the stock used, and the care and time taken in melting down and refining the metal, so as to give it density, homogeneity, and body,—those

points which show up in a long life of hard service of the boilers.

Flange Steel.—Flange grade is made from carefully selected stock, low in chemical impurities and especially adapted to stand, without injury, the heating and forming necessary for the flanged portions of the boilers, and to undergo, without injury to its toughness and strength, the strains of punching, bending, and riveting of the cylinder plates, and will make a high-class, safe boiler. Its tensile strength can be made anywhere from 50,000 to 65,000 pounds, but we recommend that in the ordinary gauges of $\frac{5}{16}$ inch to ¾ inch it should be not less than 50,000 nor more than 60,000 pounds tensile strength, with a minimum elongation of 25 per cent. in a length of 8 inches.

Marine Steel.—Marine Steel, so called because of being made especially to meet the requirements of the United States Steamboat Inspection Service, is a grade equal to Fire Box. It is made in each case to suit the specification, and can be made as soft as 50,000 pounds, or as hard as 65,000 pounds tensile strength per square inch in usual thicknesses; it is usually specified to be 60,000 pounds tensile strength. Elongation, as prescribed by United States Rules.

Fire Box Steel.—Fire Box Steel is made from especially selected stock, prepared with especial care, so as to secure, first, freedom from chemical impurities, and, second, density and fineness of texture, with freedom from

sponginess or what is called "piping," being fitted especially to stand the unequal strain caused by the local action of the fire, and to readily transmit the heat from the fire to the water, requirements which steel without life in its nature, or a spongy steel, will not fulfil successfully. Tensile strength recommended is 52,000 to 62,000 pounds, with 26 per cent. elongation in 8 inches, in usual thicknesses.

Extra Locomotive Fire Box Steel.—This is the grade most difficult to make successfully, owing to the varying conditions of fuel, water, and service the boilers will have to meet, so that the metal has to be specially adapted in each case to meet the requirements of service, as well as to comply with the rigid specifications adopted by the different Railroads or Associations. [See table on following page,—56.] This grade must have the conditions of regular Fire Box Steel mentioned above even more rigidly carried out. In our judgment, a moderately stiff grade of steel, say about 60,000 pounds tensile strength, gives the best service under average conditions, but some conditions require very soft and others quite hard steel to give the best service, as the following list of specifications of leading Railroads and Associations will show; these, of course, being based on the result of large experience in each case.

FIRE BOX STEEL SPECIFICATIONS OF LEADING RAILROADS, ASSOCIATIONS, AND LOCOMOTIVE WORKS

Name	Minimum Tensile Strength	Maximum Tensile Strength	Minimum Elongation	Minimum Carbon	Maximum Carbon	Maximum Manganese	Maximum Sulphur	Maximum Phosphorus	Maximum Silicon
Atchison, Topeka and Santa Fé Rwy,	54000	65000	25% in 8″	.15	.25	.60	.025	.035	.03
American Locomotive Co.,	52000	62000	26% in 8″	. .	. .	.50	.04	.03	. .
Baldwin Locomotive Works,	55000	65000	20% in 8″	.15	.25	.45	.035	.03	.03
Baltimore & Ohio R. R.,	55000	65000	. . . . .	.15	.25	.45	.035	.035	.03
Chicago, Rock Island & Pacific Rwy,	55000	65000	22% in 8″	.15	.25	.45	.035	.035	.03
Chicago & Northwestern Rwy,	50000	60000	26% in 8″	.12	.25	.40	.03	.03	.03
Chicago, Milwaukee & St. Paul Rwy,	52000	60000	26% in 8″	. .	. .	.45	.035	.035	. .
Chicago, Burlington & Quincy Rwy,	55000	65000	25% in 8″	.15	.25	.45	.04	.03	. .
Chesapeake & Ohio Rwy,	55000	65000	25% in 8″	.15	.25	.45	.045	.035	.03
Lehigh Valley R. R.,	55000	65000	20% in 8″	.15	.25	.45	.030	.035	.035
Long Island R. R.,	48000	55000	30% in 8″	. .	. .	.45	.035	.035	. .
Lake Shore & Michigan Southern Rwy,	50000	60000	26% in 8″	.12	.25	.45	.030	.030	.030
Northern Pacific Rwy,	55000	65000	26% in 8″	.12	.25	.40	.02	.035	.03
Pennsylvania R. R.,	55000	65000	25% in 8″	.15	.25	.45	.045	.035	.03
Philadelphia & Reading Rwy,	52000	60000	30% in 2″	. .	. .	. .	.04	.035	. .
Railway Master Mechanics' Asso'n,	52000	62000	26% in 8″	.15	.25	.50	.04	.03	. .
Southern Rwy,	55000	65000	25% in 8″	. .	. .	.	.035	.035	. .
Southern Pacific Rwy,	55000	65000	25% in 8″	.15	.25	.60	.03	.03	. .

In addition to above tests, the Railway Master Mechanics' Association and some of the principal railroads require a test for homogeneity by nicking a test piece on alternate sides in three places and breaking where nicked; a cavity more than ¼ inch long in any of the three fractures being sufficient cause for rejection of the plate.

BOILERS

and

BOILER CONSTRUCTION

Also Useful Information Relating to

CHIMNEYS, FUEL, HEAT, WATER, STEAM, ETC.

STEAM BOILERS

Generally speaking, a steam boiler is a closed metallic vessel, of suitable form to generate steam from heat, either from a fire inside or under the boiler, or from the waste gases of a puddling or other furnace, where the temperature for melting or heating purposes is necessarily very high and the heat of the outgoing flames would otherwise be wasted. It must be both tight and strong, and suitable to receive and transmit the necessary heat to the water without injury to itself, and may be of any suitable shape to fulfil these conditions.

Boilers for various purposes are known to have been used as far back as the time of the Romans, about 100 A. D., and have been constructed of many kinds of materials, mostly Cast Iron, Copper, Wrought Iron, and Steel, the last two mentioned being the best suited for hard service.

Cast Iron is too brittle, Copper is too soft as well as too expensive for general use, and in these days the advantages of Soft Steel over Wrought Iron, in the various desirable qualifications, and in the facility with which it can be cheaply manufactured and made into a boiler, make good steel the best material for general use at the present time.

Generally speaking, boilers may be divided into two classes: *internally* fired and *externally* fired. Internally fired boilers are so constructed that the fire is in a box or

casing inside the boiler, and consequently surrounded by water, much of the heat passing to the water by radiation and direct transmission through the fire-box plates, the gases being carried away by tubes or flues passing through the water, and no brick setting being needed. Of this type are Locomotive boilers, Marine boilers, Cornish, Scotch, or Lancashire boilers, and most of the Upright tubular boilers.

Externally fired boilers have the fire usually under the outside of the boiler, so that a brick casing or setting is required, the construction in most cases being such that the flames afterward pass through tubes or flues surrounded by water in the body of the boiler, or, as in the water-tube and sectional types, the flames circulate between tubes or small sections connected with each other and filled with water. Externally fired boilers include plain cylinder boilers, ordinary flue boilers, horizontal tubular boilers, and most water-tube or sectional boilers.

HORSE POWER OF BOILERS

A Committee of the American Society of Mechanical Engineers recommended 30 pounds evaporation as the unit of boiler power, and this has been generally accepted. They advised that the commercial horse power should be taken as an evaporation of 30 pounds of water from a feed-water temperature of 100° Fahr. into steam at 70 pounds gauge pressure, which may be considered to be equal to 34½ pounds of water evaporated from a feed-water temperature of 212° Fahr. into steam at the same temperature.

It was the opinion of this Committee that a boiler rated at any stated power should be capable of developing that power with easy firing, moderate draught, and ordinary fuel.

The standard, adopted by the judges at the Centennial Exhibition, of 30 pounds water per hour evaporated from 100°, for each horse power, is a fair one for both boilers and engines, and has been favorably received by engineers and steam men ; but as the same boiler may be made to do more or less work, with less or greater economy, the rating of a boiler should be based on the amount of water it will evaporate at an economical rate.

Each nominal horse power of boilers requires 1 cubic foot of water per hour.

The rate of combustion should not exceed ½ pound of coal per hour for each square foot of heating surface, except where the quantity of steam is of greater importance than economy of fuel.

Where a blast is used, the grate surface should be proportionately reduced to secure the best economy.

The accumulation of scale on the interior, and of soot on the exterior, will seriously affect the efficiency and economy of the boilers. Only ⅛ of an inch deposit of soot renders the heating surface practically useless. $\frac{1}{16}$ of an inch of scale or sediment will cause a loss of 13 per cent. in fuel. The result of a bad setting for a boiler has been known to be a loss of 21 per cent. in economy.

In common practice, and when an approximate rating is desired, it has become customary to allow a certain number of square feet of heating surface per horse power.

The following table gives the approximate square feet of heating surface per horse power in various styles of boilers:

Plain Cylinder,	6 to 10 sq. ft.
Flue Boiler,	8 " 12 "
Water Tube or Sectional,	10 " 12 "
Locomotive Boiler,	12 " 16 "
Horizontal Tubular Boiler,	12 " 15 "
Upright Tubular Boiler,	15 " 20 "

TABLE SHOWING RATIO OF HEATING SURFACE TO GRATE SURFACE

Plain Cylinder Boilers,	12 to 15 sq. ft. to 1 sq. ft. of grate.
Cylindrical Flue Boilers,	20 " 25 " " 1 " "
Cylindrical Tubular,	20 " 35 " " 1 " "
Marine Fire Tubular,	30 " 35 " " 1 " "
Marine Water Tube,	35 " 40 " " 1 " "
Locomotive Tubular,	50 " 75 " " 1 " "

As a rule, there should be 1 square foot of clean, efficient heating surface for each 3 pounds of water to be evaporated, and so arranged as to suit the character of the fuel.

Heating surface immediately over or near the fire is, of course, more valuable, particularly in slow firing; the crown sheet of fire box in a locomotive boiler, for instance, being most efficient and the last end of tubes the least efficient. Grates should have from 30 per cent. to 50 per cent. of air space.

Area over bridge wall should be $\frac{1}{7}$ of the grate surface.

Area of flue opening (anthracite coal) should be $\frac{1}{9}$ to $\frac{1}{10}$ of the grate surface.

Area of flue opening (bituminous coal) should be $\frac{1}{6}$ to $\frac{1}{7}$ of the grate surface.

Area of chimney should be $\frac{1}{8}$ to $\frac{1}{10}$ of the grate surface.

A well-designed boiler under good average conditions, with feed water heated to 200° F., should evaporate 10 pounds of water into steam at 100 pounds pressure per sq. in. for each pound of bituminous coal or 9 pounds for each pound of anthracite burned.

The proportion required of grate surface to heating surface for best results, will vary according to the conditions from $\frac{1}{10}$th to $\frac{1}{75}$th, according to rapidity of combustion and character of fuel used.

A strong draft, and free burning fuel, as wood or bituminous coal, will need a large proportion of heating surface to take up the heat from the large volume of rapidly moving heated gases, while a mild draft or a slow burning fuel, such as anthracite coal, particularly the smaller sizes, need a larger proportion of grate surface; and the heating surface so arranged that a large proportion of it will be exposed to the direct effect of the fire, because the slow movement and comparatively small volume of the after-gases can easily be taken care of by a small amount of tube or flue surface.

RATES OF COMBUSTION

	Pounds per sq. ft. per hour
With Chimney Draught:	
Slowest Rate, Cornish Boilers,	4 to 6
Ordinary Rate, Cornish Boilers,	10 to 15
Ordinary Rate, Factory Boilers,	12 to 18
Ordinary Rate, Marine Boilers,	15 to 25
Quickest Rate for Anthracite Coal,	15 to 20
Quickest Rate for Bituminous Coal,	20 to 25
With Forced Draught:	
Locomotives,	40 to 100
Torpedo Boats,	60 to 125

The following table, prepared from careful collation of French experience by Morin and Tresca, and first published by the late W. P. Trowbridge, indicates the rapidity of combustion which is to be expected with chimneys of the height.

Heights of Chimneys in Feet	Pounds of Coal per Square Foot of Section of Chimney, per Hour	Pounds of Coal per Square Foot of Grate, per Hour
20	60	7.5
25	68	8.5
30	76	9.5
35	84	10.5
40	93	11.6
50	105	13.1
60	116	14.5
70	126	15.8
80	135	16.9
90	144	18.0
100	152	19.0
110	160	20.0

PRESSURE

Rule for calculating pressure allowed on boilers according to *United States Government Rules.* [See circular of Treasury Department, Office of Supervising Inspector General of Steamboats, January, 1903.] "Multiply one-sixth of tensile strength of iron by thickness expressed in inches, or parts, and divide by half the diameter of shell, expressed in inches. The result will be pressure allowed per square inch of surface for *single riveting*, to which add 20 per cent. for *double riveting*, where all the rivet holes have been fairly drilled."

Hartford Steam Boiler Inspection and Insurance Company's Rules for Rating Maximum Working Pressure on Cylindrical Boiler Shells

In estimating the strength of the longitudinal seams, two formulæ shall be applied.

Formula (A): (Pitch of rivets) — (diameter of the holes punched to receive the rivets) ÷ (pitch of rivets) = (percentage of the strength of the solid part of the same sheet).

Formula (B): (Area of the hole filled by the rivet) × (number of rows of rivets in the seam) ÷ (pitch of rivets) × (thickness of the sheet). This product × (shearing strength of the rivet) ÷ (tensile strength of the sheet) = (percentage of the strength of the rivets in the seam as compared to the strength of the solid part of the sheet).

$$\left(\frac{A \times N}{p \times t}\right) \times \frac{S}{T} = \text{Percentage.}$$

The shearing strength of a rivet, in a composite joint made of iron rivets and steel plates, shall not be considered in excess of forty thousand (40,000) pounds.

Take the lowest of the percentages as found by formula (A) or (B) and apply that percentage as the value of the seam in the following formula (C), which determines the strength of the longitudinal seams.

Formula (C): (Thickness of the boiler plate, expressed in parts of an inch) × (value of the seam as obtained by formula A or B) × (ultimate strength of the iron in the plates) ÷ (internal radius of the boiler in

inches) $\times$ (factor of safety) = (pressure per square inch at which the safety-valve may be set).

Boiler Heads.—If the radius of the curvature of the convex head of the boiler be equal to the diameter of the shell of the boiler to which it is attached, then the metal in the head sheet must be of the same thickness as the plates used in the shell or cylindrical part, and no bracing is necessary. All flat heads must be stayed up to the value of the shell when not held by well-secured flues or tubes. Domes and manholes in the shell of the boiler must be made as strong as the other parts of the boiler, by any of the well-known methods to the satisfaction of the Inspector.

Multiply the tensile strength of the iron or steel by the thickness of the plate. Then multiply this product by the efficiency of the joint, and divide the result by the radius or half diameter of the boiler. This gives the bursting pressure, and this result divided by the factor of safety gives the safe working pressure. The factor of safety generally adopted is 5.

Using the rule given on the preceding page the strength of a properly proportioned *single* riveted joint is equal to 60 per cent. of the total strength of the plate. A properly proportioned *double* riveted joint is equal to 75 per cent.

A properly proportioned *triple* riveted joint with inside and outside welt strips is equal to 87½ per cent. In this joint the outside welt strip takes two rows of rivets, the inside strip being wide enough to take three rows; the pitch of the third row, however, is double that of the other rows. [See illustration, page 68.]

A properly proportioned *quadruple* riveted joint with inside and outside welt strips is equal to 94.6 per cent. In this joint the outside welt strip takes two rows of rivets, the inside strip being wide enough to take four rows; the outer row having four times the pitch and the next row twice the pitch of the two inner rows. [See illustration, page 69.]

This rule may be expressed as follows:

Safe working pressure =

$$\frac{\text{tensile strength} \times \text{thickness} \times \text{efficiency of joint}}{\text{radius} \times \text{factor of safety}}.$$

EXAMPLE

What is the safe working pressure of a boiler 60 inches in diameter, constructed of steel; plates ⅜ inch thick, with tensile strength of 58,000 pounds per square inch; longitudinal joint double riveted, having an efficiency of 70 per cent. of the solid plate; factor of safety 5?

$$\text{Safe pressure} = \frac{58{,}000 \times .375 \times .70}{30 \times 5} = 101.5 \text{ pounds.}$$

This rule assumes that the heads of the boiler are well braced. The strain or load on any one brace should not exceed 7500 pounds per square inch.

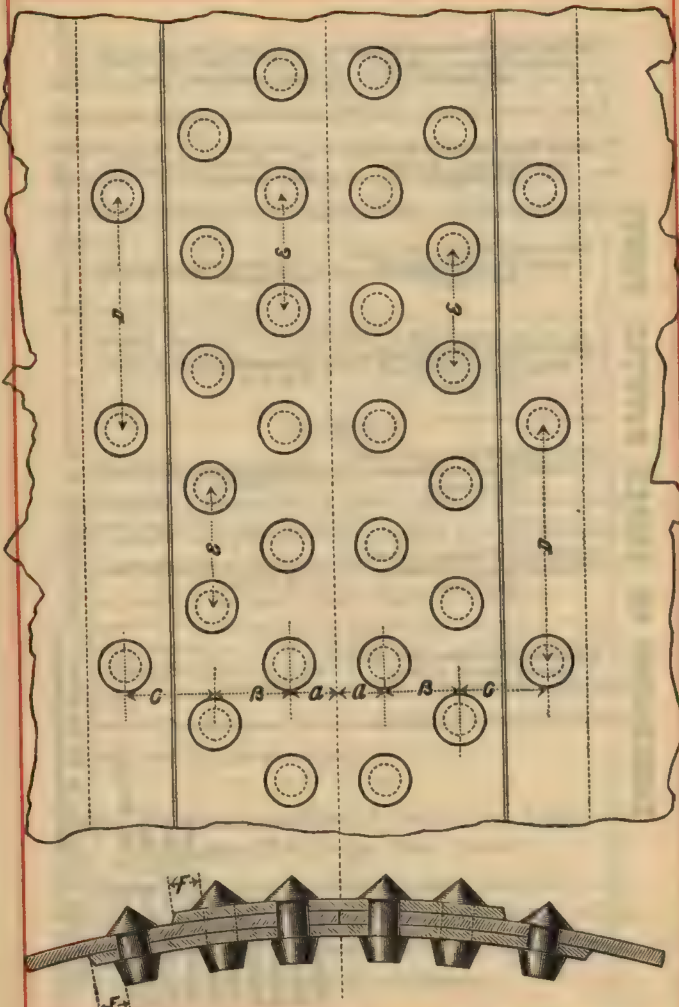
Triple and Quadruple Riveted Joints, with Inside and Outside Welt Strips (Butt Straps)

The illustrations on the following pages show Triple and Quadruple Riveted Joints with Inside and Outside Welt Strips (Butt Straps), as designed by the Hartford Steam Boiler Inspection and Insurance Company.

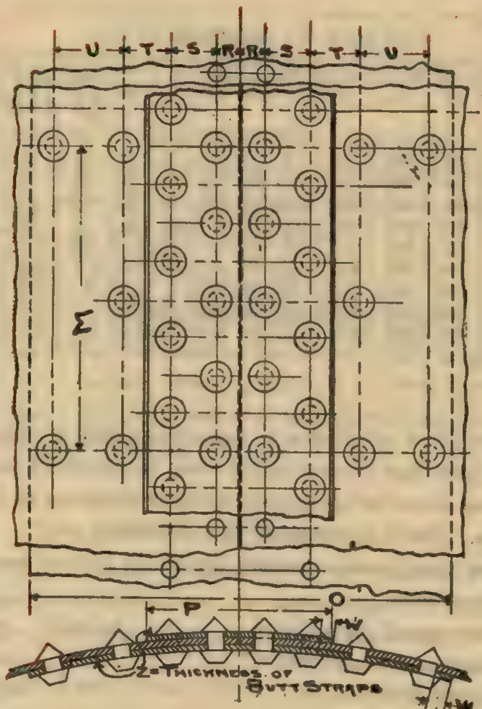
DIMENSIONS OF TRIPLE RIVETED JOINTS

	Boiler Shell 60 Inches Diameter Steam Pressure Allowed, 120 Pounds	Boiler Shell 60 Inches Diameter Steam Pressure Allowed, 138 Pounds	Boiler Shell 66 Inches Diameter Steam Pressure Allowed, 109 Pounds	Boiler Shell 66 Inches Diameter Steam Pressure Allowed, 125 Pounds	Boiler Shell 72 Inches Diameter Steam Pressure Allowed, 100 Pounds	Boiler Shell 72 Inches Diameter Steam Pressure Allowed, 115 Pounds	Boiler Shell 72 Inches Diameter Steam Pressure Allowed, 132 Pounds
Distance A,	$1\frac{7}{32}$	$1\frac{13}{32}$	$1\frac{7}{32}$	$1\frac{13}{32}$	$1\frac{7}{32}$	$1\frac{13}{32}$	$1\frac{1}{2}$
Distance B,	$2\frac{3}{16}$	$2\frac{1}{4}$	$2\frac{3}{16}$	$2\frac{1}{4}$	$2\frac{3}{16}$	$2\frac{1}{4}$	$2\frac{3}{8}$
Distance C,	$2\frac{1}{2}$	$2\frac{3}{4}$	$2\frac{1}{2}$	$2\frac{3}{4}$	$2\frac{1}{2}$	$2\frac{3}{4}$	3
Distance D,	$6\frac{1}{2}$	$6\frac{3}{4}$	$6\frac{1}{2}$	$6\frac{3}{4}$	$6\frac{1}{2}$	$6\frac{3}{4}$	$7\frac{1}{2}$
Distance E,	$3\frac{1}{4}$	$3\frac{3}{8}$	$3\frac{1}{4}$	$3\frac{3}{8}$	$3\frac{1}{4}$	$3\frac{3}{8}$	$3\frac{3}{4}$
Distance F,	$\frac{13}{16}$	$\frac{15}{16}$	$\frac{13}{16}$	$\frac{15}{16}$	$\frac{13}{16}$	$\frac{15}{16}$	1
Diameter of Rivets,	$\frac{3}{4}$	$\frac{7}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	$\frac{15}{16}$
Diameter of Holes,	$\frac{13}{16}$	$\frac{15}{16}$	$\frac{13}{16}$	$\frac{15}{16}$	$\frac{13}{16}$	$\frac{15}{16}$	1
Thickness of Plates,	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$
Thickness of Welt Strips,	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$

Factor of safety is 5 in all the above. Tensile strength is figured at 55,000 pounds, according to the uniform custom of the Hartford Insurance Company.



Triple Riveted Joint, with Inside and Outside Welt Strips (Butt Straps)



Quadruple Riveted Butt Joint

QUADRUPLE RIVETED JOINT

Thickness of Shell	Dimensions									
	M	O	P	R	S	T	U	W	Dia. of Rivets	Dia. of Rivet Holes	Z
$\frac{5}{16}$	14	$19\frac{3}{4}$	$8\frac{3}{4}$	$1\frac{1}{8}$	$2\frac{1}{8}$	$2\frac{1}{4}$	$3\frac{1}{4}$	$\frac{3}{4}$	$\frac{11}{16}$	$\frac{3}{4}$	$\frac{1}{4}$
$\frac{3}{8}$	14	$19\frac{3}{4}$	$8\frac{3}{4}$	$1\frac{1}{8}$	$2\frac{1}{8}$	$2\frac{1}{4}$	$3\frac{1}{4}$	$\frac{3}{4}$	$\frac{11}{16}$	$\frac{3}{4}$	$\frac{5}{16}$
$\frac{7}{16}$	15	22	$9\frac{3}{4}$	$1\frac{5}{16}$	$2\frac{1}{4}$	$2\frac{5}{8}$	$3\frac{1}{2}$	$\frac{7}{8}$	$\frac{13}{16}$	$\frac{7}{8}$	$\frac{3}{8}$
$\frac{1}{2}$	$15\frac{5}{8}$	$22\frac{3}{4}$	$10\frac{1}{8}$	$1\frac{13}{32}$	$2\frac{1}{4}$	$2\frac{13}{16}$	$3\frac{1}{2}$	$\frac{15}{16}$	$\frac{7}{8}$	$\frac{15}{16}$	$\frac{7}{16}$
$\frac{9}{16}$	17	$24\frac{1}{8}$	$11\frac{1}{8}$	$1\frac{1}{2}$	$2\frac{9}{16}$	3	$3\frac{1}{2}$	1	$\frac{15}{16}$	1	$\frac{7}{16}$
$\frac{5}{8}$	$15\frac{1}{2}$	$23\frac{3}{4}$	$10\frac{7}{8}$	$1\frac{19}{32}$	$2\frac{1}{4}$	$3\frac{3}{16}$	$3\frac{1}{4}$	$1\frac{1}{16}$	1	$1\frac{1}{16}$	$\frac{1}{2}$
$\frac{11}{16}$	$15\frac{5}{8}$	$24\frac{15}{16}$	$11\frac{13}{16}$	$1\frac{25}{32}$	$2\frac{11}{32}$	$3\frac{9}{16}$	3	$1\frac{3}{16}$	$1\frac{1}{8}$	$1\frac{3}{16}$	$\frac{9}{16}$
$\frac{3}{4}$	$15\frac{1}{2}$	$23\frac{3}{4}$	$10\frac{7}{8}$	$1\frac{19}{32}$	$2\frac{1}{4}$	$3\frac{3}{16}$	$3\frac{1}{4}$	$1\frac{1}{16}$	1	$1\frac{1}{16}$	$\frac{9}{16}$
$\frac{15}{16}$	$17\frac{1}{4}$	$28\frac{1}{4}$	$13\frac{1}{8}$	$1\frac{31}{32}$	$2\frac{5}{8}$	$3\frac{15}{16}$	$3\frac{5}{8}$	$1\frac{5}{16}$	$1\frac{1}{4}$	$1\frac{5}{16}$	$\frac{25}{32}$

Method of calculation to determine modes of failures of a quadruple riveted double strap butt joint for longitudinal seams, straps three-fourths the thickness of shell plates. [See " Locomotive " for November, 1896.]

Steel plate tensile strength per square inch of section 57,000 pounds.

Thickness of plate ½″ =	decimal	.50
Diameter of rivet holes 1″ =	"	1.00
Area of rivet hole =	"	0.7854
Pitch of rivets in inner rows 4⅜″ =	"	4.375
" " " " first outer row 8¾″ =	"	8.75
" " " in second outer row 17½″ =	"	17.50

Resistance of iron rivets in single shear 40,000 pounds.

" " " " " double " 74,000 "

FIRST MODE OF FAILURE

17.50″ — 1″ = 16½″ ÷ 17.50″ = 94% efficiency of joint.

SECOND MODE OF FAILURE

17.50″ × ½″ × 57,000 = 498,750 = strength of solid plate.

17.50″ — 2″ (diameter of two rivets) × ½″ × 57,000 = 441,750 + 31,416 (strength of one rivet in single shear) = 473,166 ÷ 498,750 (strength of solid plate) = 94.87 or about 95 per cent. efficiency for joint.

THIRD MODE OF FAILURE

17.50″ — 4″ (diameter of four rivets) × ½″ × 57,000 = 374,750 + 94,248 (shearing strength of three rivets) = 468,998 ÷ 498,750 (strength of solid plate) = 95.6 or about 96 per cent. efficiency for joint.

FOURTH MODE OF FAILURE

.7854″ × 74,000 × 8 (rows of rivets) = 464,952 + 94,248 (strength of three rivets in single shear) = 559,200 ÷ 498,750 = 112 per cent. efficiency of rivet shear.

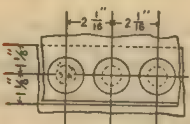
To find safe pressure from the above formulæ for 84″ diameter boiler, ½″ thick, tensile strength 57,000 pounds. Least efficiency found from first mode is 94 per cent.

94 per cent. × ½″ = 47% × 57,000 = 26,790 ÷ (42″ × 5) (internal radius and factor of five) = 127½ safe pressure to be carried.

SINGLE RIVETED GIRTH JOINTS

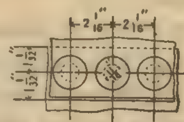
Designed and advocated by Hartford Steam Boiler Inspection and Insurance Co.

FOR BOILER 1-4 IN. THICK
When longit'l seams are Double Riveted.



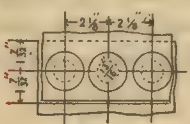
Rivets 11/16 in. diameter.

FOR BOILER 1-4 IN. THICK
When longit'l seams are Triple Riveted.



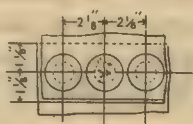
Rivets 5/8 in. diameter.

FOR BOILER 5-16 IN. THICK
When longit'l seams are Double Riveted.



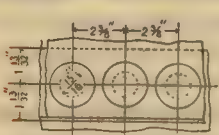
Rivets 3/4 in. diameter.

FOR BOILER 5-16 IN. THICK
When longit'l seams are Triple Riveted.



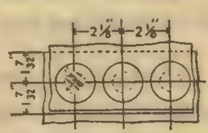
Rivets 11/16 in. diameter.

FOR BOILER 3-8 IN. THICK
When longit'l seams are Double Riveted.



Rivets 7/8 in. diameter.

FOR BOILER 3-8 IN. THICK
When longit'l seams are Triple Riveted.



Rivets 3/4 in. diameter.

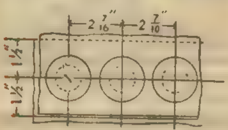
See pages 74 and 75 for details of Longitudinal Seams.

SINGLE RIVETED GIRTH JOINTS—Con.

Designed and advocated by Hartford Steam Boiler Inspection and Insurance Co.

FOR BOILER 7-16 IN. THICK

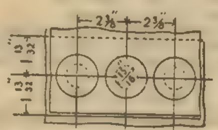
When longit'l seams are Double Riveted.



Rivets $\frac{15}{16}$ in. diameter.

FOR BOILER 7-16 IN. THICK

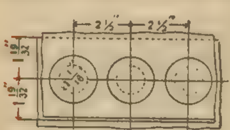
When longit'l seams are Triple Riveted.



Rivets $\frac{7}{8}$ in. diameter.

FOR BOILER 1-2 IN. THICK

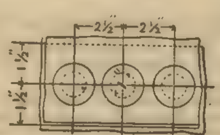
When longit'l seams are Double Riveted.



Rivets 1 in. diameter.

FOR BOILER 1-2 IN. THICK

When longit'l seams are Triple Riveted.

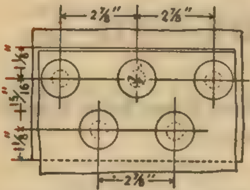


Rivets $\frac{15}{16}$ in. diameter.

See pages 74 and 75 for details of Longitudinal Seams.

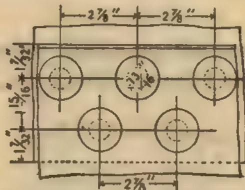
LONGITUDINAL RIVETED JOINTS

Designed and advocated by Hartford Steam Boiler Inspection and Insurance Co.



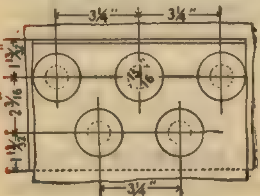
DOUBLE RIVETED LAP JOINT FOR 1-4 IN. PLATES

Holes ¾ inch diameter.
Rivets $\frac{11}{16}$ inch diameter.
Efficiency = $\frac{74}{100}$ of solid plate.
Tensile Strength 60,000 pounds.
Shearing Strength 38,000 pounds.



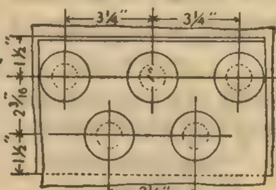
DOUBLE RIVETED LAP JOINT FOR 5-16 IN. PLATES

Holes $\frac{13}{16}$ inch diameter.
Rivets ¾ inch diameter.
Efficiency = $\frac{72}{100}$ of solid plate.
Tensile Strength 60,000 pounds.
Shearing Strength 38,000 pounds.



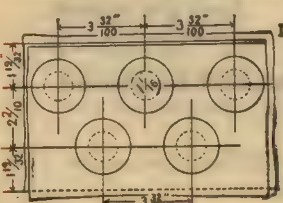
DOUBLE RIVETED LAP JOINT FOR 3-8 IN. PLATES

Holes $\frac{15}{16}$ inch diameter.
Rivets ⅞ inch diameter.
Efficiency = $\frac{70}{100}$ of solid plate.
Tensile Strength 60,000 pounds.
Shearing Strength 38,000 pounds.



DOUBLE RIVETED LAP JOINT FOR 7-16 IN. PLATES

Holes 1 inch diameter.
Rivets $\frac{15}{16}$ inch diameter.
Efficiency = $\frac{70}{100}$ of solid plate.
Tensile Strength 60,000 pounds.
Shearing Strength 38,000 pounds.



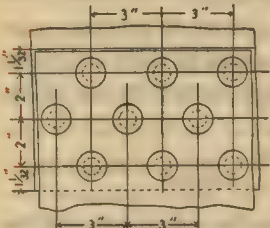
DOUBLE RIVETED LAP JOINT FOR 1-2 IN. PLATES

Holes $1\frac{1}{16}$ inch diameter.
Rivets 1 inch diameter.
Efficiency = $\frac{68}{100}$ of solid plate.
Tensile Strength 60,000 pounds.
Shearing Strength 38,000 pounds.

See pages 72 and 73 for details of Girth Joints.

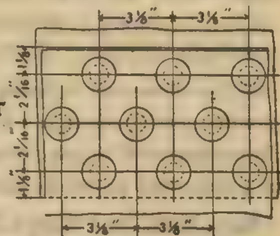
LONGITUDINAL RIVETED JOINTS—Con.

Designed and advocated by Hartford Steam Boiler Inspection and Insurance Co.



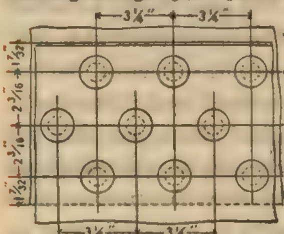
TRIPLE RIVETED LAP JOINT FOR 1-4 IN. PLATES

Holes $\frac{11}{16}$ inch diameter.
Rivets $\frac{5}{8}$ inch diameter.
Efficiency $= \frac{77}{100}$ of solid plate.
Tensile Strength 60,000 pounds.
Shearing Strength 38,000 pounds.



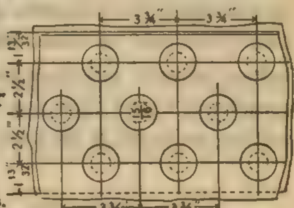
TRIPLE RIVETED LAP JOINT FOR 5-16 IN. PLATES

Holes $\frac{3}{4}$ inch diameter.
Rivets $\frac{11}{16}$ inch diameter.
Efficiency $= \frac{78}{100}$ of solid plate.
Tensile Strength 60,000 pounds.
Shearing Strength 38,000 pounds.



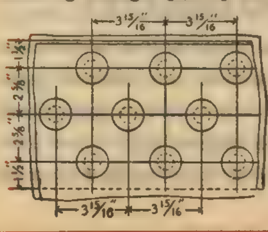
TRIPLE RIVETED LAP JOINT FOR 3-8 IN. PLATES

Holes $\frac{13}{16}$ inch diameter.
Rivets $\frac{3}{4}$ inch diameter.
Efficiency $= \frac{78}{100}$ of solid plate.
Tensile Strength 60,000 pounds.
Shearing Strength 38,000 pounds.



TRIPLE RIVETED LAP JOINT FOR 7-16 IN. PLATES

Holes $\frac{15}{16}$ inch diameter.
Rivets $\frac{7}{8}$ inch diameter.
Efficiency $= \frac{78}{100}$ of solid plate.
Tensile Strength 60,000 pounds.
Shearing Strength 38,000 pounds.



TRIPLE RIVETED LAP JOINT FOR 1-2 IN. PLATES

Holes 1 inch diameter.
Rivets $\frac{15}{16}$ inch diameter.
Efficiency $= \frac{75}{100}$ of solid plate.
Tensile Strength 60,000 pounds.
Shearing Strength 38,000 pounds.

See pages 72 and 73 for details of Girth Joints.

Cylindrical Furnaces and Flues.—Boiler flues and furnaces of cylindrical form submitted to external pressure, tending to cause the cylinder to collapse, when formed of wrought-iron plates united by rivets and all the seams made with lap joints, shall be rated by the following rule:

$$\frac{89{,}600 \times \text{thickness}^2}{\text{Length (in feet)} \times \text{Diam. (in inches)}} = \text{Safe load.}$$

N. B.—This rule is based on the assumption that the circumferential seams act as reinforcements, and reduce the unsupported length of the flue or furnace to the length of the sections joined by the circumferential seams.

Stay-Bolts and Stays.—The area of stay-bolts and stays submitted to strain shall be measured at their least section, and one-fifth of the breaking strength of the iron shall be assumed as the safe working load, if the ductility test of the iron does not exceed fifteen per cent.; but may be taken at one-fourth, when the ductility test shows twenty per cent. or over. The allowable strain on stay-bolts or stays of unknown quality of iron shall never be considered higher than 7500 pounds per square inch of section, measured at the point of least section.

ATTACHMENTS AND INDICATORS

Feeding Apparatus.—There shall be for each boiler or series of connected boilers at least one efficient feeding apparatus, and in case there is but one such apparatus, and it be worked by an engine employed for other purposes, this feeding apparatus shall be of such character

and construction that it can be examined and repaired in all its parts while the engine is in motion.

Gauge Cocks.—Each boiler shall have upon it three gauge cocks, and one glass water-gauge, or in place of the gauge cocks a second glass water-gauge. Each should have an independent connection with the boiler itself. If one connecting pipe is used for both apparatus, it must be at least nine square inches area (cross sectional), and all the connections to which shall be made with not less than one and one-quarter (1¼) inch pipe. Gauge cocks, when used, must be so placed that the middle gauge must be at least four inches above the top of the flues, tubes, or crown of the fire box. The lowest point of vision of the water in glass gauge must be above the top of flues, tubes, or crown of the fire box.

Steam Gauge.—There shall be for each boiler or series of boilers connected in one range at least one good and reliable steam pressure gauge attached, without the intervention of any valve except its own.

Boilers Over One Fire.—Every range of boilers over one fire shall be so connected by steam and feed pipes that a uniform level of water may be maintained therein.

Lever Safety-Valves.—Every boiler, when fired separately, and every set or series of boilers when placed over one fire, shall have attached thereto, without the interposition of any other valve, two or more safety valves, the aggregate area of which shall have such relations to the area of the grate and the pressure within the boiler as per rule on page 79; and every safety-valve shall have an

arm or bearer distinctly notched and marked with five pounds or ten pounds divisions, and shall have but one "P" or ball for a weight. The weight of said "P" or ball is to be determined by the Inspector, the pounds and ounces of which shall be stamped or plainly marked on the weight and on the lever, and a record of the same is to be kept in the office of the Inspector; and the arm shall not have greater length than will allow the "P" to be placed so as to produce on the boiler the maximum pressure which the certificate authorizes to be carried.

The least aggregate area of safety valve (being the least sectional area for the discharge of steam) to be placed upon all stationary boilers with natural or chimney draft (see notes A and B) shall be obtained by multiplying the area of grate surface by the figures found under the desired pressure in the following table.

[Note "A."] Where boilers have a forced or artificial draft, the Inspector must estimate the area of grate at the rate of one square foot of grate surface for each sixteen pounds of fuel burned on the average per hour.

[Note "B."] When boilers are heated by waste heat of furnaces or otherwise than by fire on grates, the proper grate area is to be estimated by the Inspector.

PRESSURE DESIRED

10	20	30	40	50	60	70	80	90	100	110	120
1.21	0.79	0.58	0.46	0.38	0.33	0.29	0.25	0.23	0.21	0.19	0.17

(The figures in the upper row indicate pressures; those

in the lower indicate the area of valve corresponding to one square foot of grate surface.)

Example—Boiler 25 square feet of grate area and sixty pounds of pressure.

For one square foot (from table) 0.33
25 square feet.

8.25 square inches.

This would call for two safety-valves, each with 4.125 square inches area or 2.29 inches in diameter.

The constants in the foregoing table are obtained as follows:

$$\frac{22.5}{\text{Desired pressure} + 8.62} = \left\{ \begin{array}{c} \text{Area of safety-valve for} \\ \text{one square foot of} \\ \text{grate surface.} \end{array} \right.$$

For pressures not given in this table, the above formula may be used.

Spring Safety-Valves.—The Inspector shall have authority to grant to any user or users of steam boilers to place thereon any spring safety-valve which has been, or may hereafter be, approved by the United States Board of Supervising Inspectors of Steam Vessels.

Hydrostatic Test.—All new stationary steam boilers erected or to be erected, where they come under the provisions of the Act, must be inspected either at the shop where made or at the place of erection, and shall be submitted to a hydrostatic test of one-third greater than the boiler is rated to carry, preferably before the walls are built about them, in order that all parts may be readily seen by the Inspector.

Openings in Boilers to Facilitate Inspection.—All boilers shall be provided with man or hand-holes, through which an inspection of the interior of the boiler can be made. Horizontal return tubular boilers should have two manholes, one above and one below the tubes, the latter for cleaning and inspection of the parts that lie immediately over the fire and hot gases.

HORIZONTAL TUBULAR BOILER SETTING

(Designed and Adopted by Lukens Iron and Steel Company)

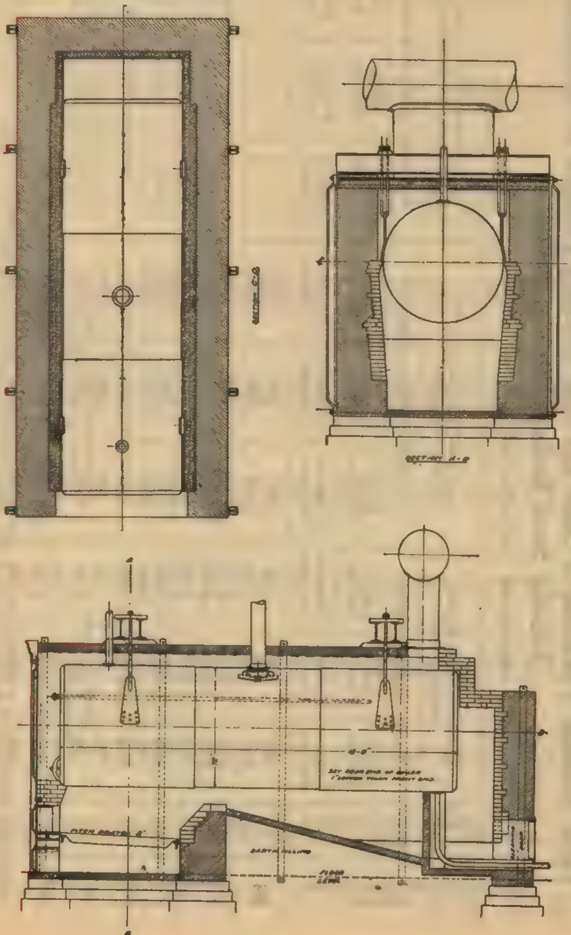


Table Showing Thickness of Shell and Safe Working Pressure for Horizontal Tubular Steel Boilers, Without Domes

ACCORDING TO RULES OF CITY OF PHILADELPHIA

Diameter of Shell Inches	Thickness of Shell Inches	Longitudinal Seams Single Riveted — Tensile Strength of Steel			Longitudinal Seams Double Staggered Riveted — Tensile Strength of Steel			Longitudinal Seams Double Triple Riveted Butt Joint — Tensile Strength of Steel		
		50000 Pounds	55000 Pounds	60000 Pounds	50000 Pounds	55000 Pounds	60000 Pounds	50000 Pounds	55000 Pounds	60000 Pounds
		Pressure Pounds	Pressure Pounds	Pressure Pounds	Pressure Pounds	Pressure Pounds	Pressure Pounds	Pressure Pounds	Pressure Pounds	Pressure Pounds
24	$\frac{1}{4}$	118	130	142	145	160	174	. . . .	. . . .	. . . .
	$\frac{5}{16}$	148	163	178	182	200	218	. . . .	. . . .	. . . .
28	$\frac{1}{4}$	101	112	122	125	137	150	. . . .	. . . .	. . . .
	$\frac{5}{16}$	127	139	152	156	171	187	. . . .	. . . .	. . . .
30	$\frac{1}{4}$	95	104	114	116	128	140	. . . .	. . . .	. . . .
	$\frac{5}{16}$	118	130	142	145	160	175	. . . .	. . . .	. . . .
34	$\frac{1}{4}$	83	92	100	102	113	123	. . . .	. . . .	. . . .
	$\frac{5}{16}$	104	115	125	128	141	154	. . . .	. . . .	. . . .
36	$\frac{1}{4}$	79	87	95	97	106	116	. . . .	. . . .	. . . .
	$\frac{5}{16}$	98	108	118	121	133	145	. . . .	. . . .	. . . .
38	$\frac{1}{4}$	75	82	90	92	101	110	. . . .	. . . .	. . . .
	$\frac{5}{16}$	93	103	112	115	126	138	. . . .	. . . .	. . . .
40	$\frac{9}{32}$	80	88	96	98	108	118	. . . .	. . . .	. . . .
	$\frac{5}{16}$	89	97	106	109	120	131	. . . .	. . . .	. . . .

Table Showing Thickness of Shell and Safe Working Pressure, Etc.—Continued

Diameter of Shell Inches	Thickness of Shell Inches	Longitudinal Seams Single Riveted			Longitudinal Seams Double Staggered Riveted			Longitudinal Seams Double Triple Riveted Butt Joint		
		Tensile Strength of Steel			Tensile Strength of Steel			Tensile Strength of Steel		
		50000 Pounds	55000 Pounds	60000 Pounds	50000 Pounds	55000 Pounds	60000 Pounds	50000 Pounds	55000 Pounds	60000 Pounds
		Pressure Pounds	Pressure Pounds	Pressure Pounds	Pressure Pounds	Pressure Pounds	Pressure Pounds	Pressure Pounds	Pressure Pounds	Pressure Pounds
42	$\frac{9}{32}$	76	84	91	93	103	112	. . . .	. . . .	. . . .
	$\frac{5}{16}$	84	93	101	104	114	125	. . . .	. . . .	. . . .
44	$\frac{3}{10}$	77	85	93	95	105	114	. . . .	. . . .	. . . .
	$\frac{32}{100}$	82	91	99	101	112	122	. . . .	. . . .	. . . .
46	$\frac{5}{16}$	77	85	92	95	104	114	. . . .	. . . .	. . . .
	$\frac{34}{100}$	84	92	101	103	113	124	. . . .	. . . .	. . . .
48	$\frac{32}{100}$	76	83	91	93	102	112	114	126	137
	$\frac{36}{100}$	85	94	102	105	115	126	129	141	154
50	$\frac{33}{100}$	75	82	90	92	101	110	113	124	136
	$\frac{36}{100}$	82	90	98	100	110	120	123	136	148
52	$\frac{34}{100}$	74	81	89	91	100	109	112	123	134
	$\frac{36}{100}$	78	86	94	96	106	116	119	130	142
54	$\frac{36}{100}$	76	83	91	93	102	112	114	126	137
	$\frac{3}{8}$	79	86	95	97	106	116	119	131	143
56	$\frac{3}{8}$	76	83	91	93	103	112	115	126	138
	$\frac{4}{10}$	81	89	97	100	110	120	122	135	147

Table Showing Thickness of Shell and Safe Working Pressure, Etc.—Continued

Diameter of Shell Inches	Thickness of Shell Inches	Longitudinal Seams Single Riveted			Longitudinal Seams Double Staggered Riveted			Longitudinal Seams Double Triple Riveted Butt Joint		
		Tensile Strength of Steel			Tensile Strength of Steel			Tensile Strength of Steel		
		50000 Pounds	55000 Pounds	60000 Pounds	50000 Pounds	55000 Pounds	60000 Pounds	50000 Pounds	55000 Pounds	60000 Pounds
		Pressure Pounds	Pressure Pounds	Pressure Pounds	Pressure Pounds	Pressure Pounds	Pressure Pounds	Pressure Pounds	Pressure Pounds	Pressure Pounds
60	$\frac{4}{10}$	76	83	91	93	102	112	114	126	137
	$\frac{42}{100}$	79	87	95	98	107	117	120	132	144
66	$\frac{43}{100}$	74	81	89	91	100	109	112	123	134
	$\frac{45}{100}$	77	85	93	95	105	114	117	129	140
72	$\frac{45}{100}$	71	78	85	87	96	105	107	118	129
	$\frac{48}{100}$	76	83	91	93	102	112	114	126	137
78	$\frac{45}{100}$	65	72	78	80	88	96	99	109	119
	$\frac{1}{2}$	73	80	87	89	98	107	110	121	132
84	$\frac{45}{100}$	61	67	73	75	82	90	92	101	110
	$\frac{1}{2}$	67	74	81	83	91	100	102	112	122

In the above table a factor of safety of 5 was used and strength of seams as follows:

57 per cent. for single riveting,
70 per cent. for double staggered,
86 per cent. for triple riveting.

Dimensions and Areas of Standard Boiler Tubes

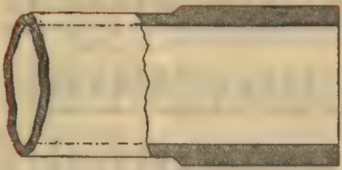
Diameter		Thickness		Circumference		Transverse Areas			Length of Tube per Square Foot		Nominal Weight Per Foot Pounds
O. D.	I. D.	Ins.	Nearest B. W. G.	External	Internal	External	Internal	Metal	Ex. Surf.	In. Surf.	
1	.810	.095	13	3.142	2.545	.7854	.5153	.2701	3.819	4.715	.90
1¼	1.060	.095	13	3.927	3.330	1.2272	.8825	.3447	3.056	3.603	1.15
1½	1.310	.095	13	4.712	4.115	1.7671	1.3478	.4193	2.547	2.916	1.40
1¾	1.560	.095	13	5.498	4.901	2.4053	1.9113	.4940	2.183	2.448	1.66
2	1.810	.095	13	6.283	5.686	3.1416	2.5730	.5686	1.909	2.110	1.91
2¼	2.060	.095	13	7.069	6.472	3.9761	3.3329	.6432	1.698	1.854	2.16
2½	2.282	.109	12	7.854	7.169	4.9087	4.0899	.8188	1.528	1.674	2.75
2¾	2.532	.109	12	8.639	7.954	5.9396	5.0349	.9047	1.389	1.508	3.04
3	2.782	.109	12	9.425	8.740	7.0686	6.0787	.9899	1.273	1.373	3.33
3¼	3.010	.120	11	10.210	9.456	8.2958	7.1157	1.1801	1.175	1.269	3.96
3½	3.260	.120	11	10.996	10.242	9.6211	8.3469	1.274	1.091	1.171	4.28
3¾	3.510	.120	11	11.781	11.027	11.045	9.6762	1.369	1.018	1.088	4.6
4	3.732	.134	10	12.566	11.724	12.566	10.939	1.627	.955	1.024	5.47
4½	4.232	.134	10	14.137	13.295	15.904	14.066	1.838	.849	.902	6.17
5	4.704	.148	9	15.708	14.778	19.635	17.379	2.256	.764	.812	7.58
6	5.670	.165	8	18.850	17.813	28.274	25.249	3.025	.637	.673	10.16
7	6.670	.165	8	21.991	20.954	38.485	34.941	3.544	.546	.573	11.9

Dimensions and Areas of Standard Boiler Tubes—Continued

Diameter		Thickness		Circumference		Transverse Areas			Length of Tube Per Square Foot		Nominal Weight Per Foot Pounds
O. D.	I. D.	Inches	Nearest B. W. G.	External	Internal	External	Internal	Metal	Ex. Surf.	In. Surf.	
8	7.670	.165	8	25.133	24.096	50.265	46.204	4.061	.477	.498	13.65
9	8.640	.180	7	28.274	27.143	63.617	58.629	4.988	.424	.442	16.76
10	9.594	.203	6	31.416	30.140	78.540	72.291	6.249	.382	.398	21.00
11	10.560	.220	5	34.558	33.175	95.033	87.582	7.451	.347	.362	25.00
12	11.542	.229	4½	37.699	36.260	113.10	104.63	8.47	.319	.330	28.50
13	12.524	.238	4	40.841	39.345	132.73	123.19	9.54	.294	.305	32.06
14	13.594	.248	3½	43.982	42.424	153.94	143.22	10.72	.273	.283	36.00
15	14.482	.259	3	47.124	45.496	176.71	164.72	11.99	.254	.264	40.60
16	15.460	.270	2½	50.265	48.569	201.06	187.71	13.35	.239	.247	45.20
18	17.432	.284	2	56.549	54.764	254.47	238.66	15.81	.212	.219	53.00
20	19.376	.312	1	62.832	60.872	314.16	294.86	19.30	.190	.197	65.00
22	21.314	.343	0	69.115	66.960	380.13	356.80	23.33	.173	.179	78.00
24	23.25	.375	00	75.398	73.042	452.39	424.56	27.83	.159	.164	93.00
26	25.25	.375	00	81.681	79.325	530.93	500.74	30.19	.147	.151	101.00
28	27.25	.375	00	87.965	85.608	615.75	583.21	32.54	.136	.140	109.00
30	29.25	.375	00	94.248	91.892	706.86	671.96	34.90	.127	.130	117.00

Dimensions and Areas of Special Brands Locomotive Boiler Tubes

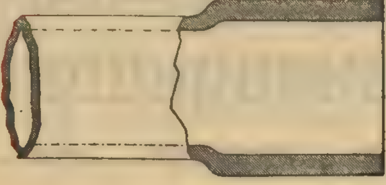
Diameter		Thickness		Circumference		Transverse Areas			Length of Tube per Square Foot		Nom. Wgt. per ft. Pounds
Ext.	Internal	Dec.	B. W. G.	External	Internal	External	Internal	Metal	Ex. Surf.	In. Surf.	
1	.810	.095	13	3.142	2.545	.7854	.5153	.2701	3.819	4.715	.90
1¼	1.060	.095	13	3.927	3.330	1.2272	.8825	.3447	3.056	3.603	1.15
1½	1.310	.095	13	4.712	4.115	1.7671	1.3478	.4193	2.547	2.916	1.40
1¾	1.532	.109	12	5.498	4.813	2.4053	1.8433	.5620	2.183	2.493	1.87
2	1.782	.109	12	6.283	5.598	3.1416	2.4941	.6475	1.909	2.144	2.17
2	1.760	.120	11	6.283	5.529	3.1416	2.4329	.7087	1.909	2.171	2.38
2	1.732	.134	10	6.283	5.441	3.1416	2.3560	.7856	1.909	2.205	2.64
2¼	2.032	.109	12	7.069	6.384	3.9761	3.2429	.7332	1.698	1.880	2.45
2¼	2.010	.120	11	7.069	6.315	3.9761	3.1731	.8030	1.698	1.900	2.70
2¼	1.982	.134	10	7.069	6.227	3.9761	3.0853	.8908	1.698	1.927	2.99
2½	2.260	.120	11	7.854	7.100	4.9087	4.0115	.8972	1.528	1.69	3.00
2½	2.232	.134	10	7.854	7.012	4.9087	3.9127	.9960	1.528	1.711	3.35
2½	2.204	.148	9	7.854	6.924	4.9087	3.8152	1.0935	1.528	1.733	3.67
2¾	2.510	.120	11	8.639	7.885	5.9396	4.9481	.9915	1.389	1.522	3.31
3	2.760	.120	11	9.425	8.671	7.0686	5.9828	1.086	1.273	1.384	3.63
3	2.732	.134	10	9.425	8.583	7.0686	5.8621	1.2065	1.273	1.398	4.05
3	2.704	.148	9	9.425	8.495	7.0686	5.7425	1.3261	1.273	1.413	4.46
3¼	2.982	.134	10	10.210	9.368	8.2958	6.9840	1.312	1.175	1.281	4.39
3½	3.232	.134	10	10.996	10.154	9.6211	8.2041	1.417	1.091	1.182	4.74
3¾	3.482	.134	10	11.781	10.939	11.045	9.522	1.523	1.018	1.097	5.09
4	3.704	.148	9	12.566	11.636	12.566	10.775	1.791	.955	1.031	6.00



PLAIN UPSET.

Upset Tubes are becoming very generally used for Marine Boiler work ; in many cases the ordinary, as well as the Stay Tubes, are thickened or upset on ends, greater durability and strength being claimed for same.

The difficulties encountered in upsetting ends of tubes are not generally appreciated, and upsets are often asked for that are either very difficult or practically impossible to make. As a guide for ordering such tubes the following tables have been prepared by the National Tube Company, showing the practicable limits that should be observed in tubes of this kind. If a greater diameter is required for upset end than that shown on table giving maximum upset, this can be accomplished by expanding the end after upsetting as is shown in the cut below. The tables are all based on an upset 2½ inches long, which is the usual length for Boiler Stay Tubes. If shorter length will answer a heavier upset than those shown on maximum table can be secured.



UPSET AND SWELLED.

TABLE SHOWING ORDINARY UPSET FOR TUBES

Thickness of Tubes in B. W. G. and Fraction of Inch	Thickness of Tubes in Decimal of Inch	Outside Diameter in Inches															
		1½	1¾	2	2¼	2½	2¾	3	3¼	3½	3¾	4	4¼	4½	4¾	5	
10	.134	1.63	1.88	2.13	2.38	2.63	2.88	3.13	3.38	3.63	3.88	4.13	4.38	4.63	4.88	5.13	Outside Diameter of Upset
9	.148	1.65	1.90	2.15	2.40	2.65	2.90	3.15	3.40	3.65	3.90	4.15	4.40	4.65	4.90	5.15	" "
8	.165	1.67	1.92	2.17	2.42	2.67	2.92	3.17	3.42	3.67	3.92	4.17	4.42	4.67	4.92	5.17	" "
7	.188	1.69	1.94	2.19	2.44	2.69	2.94	3.19	3.44	3.69	3.94	4.19	4.44	4.69	4.94	5.19	" "
6	.203	1.70	1.95	2.20	2.45	2.70	2.95	3.20	3.45	3.70	3.95	4.20	4.45	4.70	4.95	5.20	" "
5	.219	1.72	1.97	2.22	2.47	2.72	2.97	3.22	3.47	3.72	3.97	4.22	4.47	4.72	4.97	5.22	" "
4	.238	1.74	1.98	2.24	2.49	2.74	2.98	3.24	3.49	3.74	3.98	4.24	4.49	4.74	4.98	5.24	" "
$\frac{1}{4}$	.250	1.75	2.00	2.25	2.50	2.75	3.00	3.25	3.50	3.75	4.00	4.25	4.50	4.75	5.00	5.25	" "
$\frac{9}{32}$	.281	1.78	2.03	2.28	2.53	2.78	3.03	3.28	3.53	3.78	4.03	4.28	4.53	4.78	5.03	5.28	" "
$\frac{5}{16}$	.313	1.81	2.06	2.31	2.56	2.81	3.06	3.31	3.56	3.81	4.06	4.31	4.56	4.81	5.06	5.31	" "
$\frac{11}{32}$	.344	1.84	2.09	2.34	2.59	2.84	3.09	3.34	3.59	3.84	4.09	4.34	4.59	4.84	5.09	. .	" "
$\frac{3}{8}$	.375	1.88	2.13	2.38	2.63	2.88	3.13	3.38	3.63	3.88	4.13	4.38	4.63	4.88	. .	. .	" "
$\frac{13}{32}$	.406	1.91	2.16	2.41	2.66	2.91	3.16	3.41	3.66	3.91	4.16	4.41	4.66	. .	. .	. .	" "
$\frac{7}{16}$	.438	1.94	2.19	2.44	2.69	2.94	3.19	3.44	3.69	3.94	4.19	4.44	. .	. .	. .	. .	" "

Length of Upset 2½ inches

TABLE SHOWING ADVISABLE LIMITS OF UPSETS FOR TUBES

Thickness of Tubes in B. W. G. and Fraction of Inch	Thickness of Tubes in Decimal of Inch	Outside Diameter in Inches															
		$1\frac{1}{2}$	$1\frac{3}{4}$	2	$2\frac{1}{4}$	$2\frac{1}{2}$	$2\frac{3}{4}$	3	$3\frac{1}{4}$	$3\frac{1}{2}$	$3\frac{3}{4}$	4	$4\frac{1}{4}$	$4\frac{1}{2}$	$4\frac{3}{4}$	5	
10	.134	1.70	1.95	2.20	2.45	2.70	2 95	3.20	3.45	3.70	3.95	4.20	4.45	4.70	4.95	5.20	Outside Diameter of Upset
9	.148	1.72	1.97	2.22	2.47	2.72	2.97	3.22	3.47	3.72	3.97	4.22	4.47	4.72	4.97	5.22	“ “
8	.165	1.75	2.00	2.25	2.50	2.75	3.00	3.25	3.50	3.75	4.00	4.25	4.50	4.75	5.00	5.25	“ “
7	.188	1.78	2.03	2.28	2.53	2.78	3.03	3.28	3.53	3.78	4.03	4.28	4.53	4.78	5.03	5.28	“ “
6	.203	1.80	2.05	2.30	2.55	2.80	3.05	3.30	3.55	3.80	4.05	4.30	4.55	4.80	5.05	5.30	“ “
5	.219	1.83	2.08	2.33	2.58	2.83	3.08	3.33	3.58	3.83	4.08	4.33	4.58	4.83	5.08	5.33	“ “
4	.238	1.86	2.11	2.36	2.61	2.86	3.11	3.36	3.61	3.86	4.11	4.36	4.61	4.86	5.11	5.36	“ “
$\frac{1}{4}$	.250	1.88	2.13	2.38	2.63	2.88	3.13	3.38	3.63	3.88	4.13	4.38	4.63	4.88	5.13	5.38	“ “
$\frac{9}{32}$	.281	1.92	2.17	2.42	2.67	2.92	3.17	3.42	3.67	3.92	4.17	4.42	4.67	4.92	5.17	5.42	“ “
$\frac{5}{16}$	.313	1.97	2.22	2.47	2.72	2.97	3.22	3.47	3.72	3.97	4.22	4.47	4.72	4.97	5.22	5.47	“ “
$\frac{11}{32}$	.344	2.02	2.27	2.52	2.77	3.02	3.27	3.52	3.77	4.02	4.27	4.52	4.77	5.02	5.27	. .	“ “
$\frac{3}{8}$	.375	2.06	2.31	2.56	2.81	3.06	3.31	3.56	3.81	4.06	4.31	4.56	4.81	5.06	. .	. .	“ “
$\frac{13}{32}$	.406	2.11	2.36	2.61	2.86	3.11	3.36	3.61	3.86	4.11	4.36	4.61	4.86	. .	. .	. .	“ “
$\frac{7}{16}$	.438	2.16	2.41	2.66	2.91	3.16	3.41	3.66	3.91	4.16	4.41	4.66	. .	. .	. .	. .	“ “

Length of Upset $2\frac{1}{2}$ inches

TABLE SHOWING POSSIBLE UPSETS (BUT DIFFICULT) FOR TUBES

Thickness of Tubes in B. W. G. and Fraction of Inch	Thickness of Tubes in Decimal of Inch	Outside Diameter in Inches															
		$1\frac{1}{2}$	$1\frac{3}{4}$	2	$2\frac{1}{4}$	$2\frac{1}{2}$	$2\frac{3}{4}$	3	$3\frac{1}{4}$	$3\frac{1}{2}$	$3\frac{3}{4}$	4	$4\frac{1}{4}$	$4\frac{1}{2}$	$4\frac{3}{4}$	5	
10	.134	1.77	2.02	2.27	2.52	2.77	3.02	3.27	3.52	3.77	. .	. .	. .	. .	. .	. .	Outside Diameter of Upset
9	.148	1.80	2.05	2.30	2.55	2.80	3.05	3.30	3.55	3.80	4.05	4.30	. .	. .	. .	. .	" "
8	.165	1.83	2.08	2.33	2.58	2.83	3.08	3.33	3.58	3.83	4.08	4.33	4.58	4.83	. .	. .	" "
7	.188	1.88	2.13	2.38	2.63	2.88	3.13	3.38	3.63	3.88	4.13	4.38	4.63	4.88	5.13	5.38	" "
6	.203	1.91	2.16	2.41	2.66	2.91	3.16	3.41	3.66	3.91	4.16	4.41	4.66	4.91	5.16	5.41	" "
5	.219	1.94	2.19	2.44	2.69	2.94	3.19	3.44	3.69	3.94	4.19	4.44	4.69	4.94	5.19	5.44	" "
4	.238	1.98	2.23	2.48	2.73	2.98	3.23	3.48	3.73	3.98	4.23	4.48	4.73	4.98	5.23	5.48	" "
$\frac{1}{4}$	.250	2.00	2.25	2.50	2.75	3.00	3.25	3.50	3.75	4.00	4.25	4.50	4.75	5.00	5.25	5.50	" "
$\frac{9}{32}$	.281	2.06	2.31	2.56	2.81	3.06	3.31	3.56	3.81	4.06	4.31	4.56	4.81	5.06	5.31	5.56	" "
$\frac{5}{16}$	.313	2.13	2.38	2.63	2.88	3.13	3.38	3.63	3.88	4.13	4.38	4.63	4.88	5.13	5.38	5.63	" "
$\frac{11}{32}$	.344	2.19	2.44	2.69	2.94	3.19	3.44	3.69	3.94	4.19	4.44	4.69	4.94	5.19	5.44	. .	" "
$\frac{3}{8}$	.375	2.25	2.50	2.75	3.00	3.25	3.50	3.75	4.00	4.25	4.50	4.75	5.00	5.25	. .	. .	" "
$\frac{13}{32}$	.406	2.31	2.56	2.81	3.06	3.31	3.56	3.81	4.06	4.31	4.56	4.81	5.06	. .	. .	. .	" "
$\frac{7}{16}$	.438	2.38	2.63	2.88	3.13	3.38	3.63	3.88	4.13	4.38	4.63	4.88	. .	. .	. .	. .	" "

Length of Upset $2\frac{1}{2}$ inches

Bursting and Collapsing Pressures of Wrought Iron Tubes

(D. K. CLARK)

External Diameter	Thickness.	Bursting Per Sq. In. of Internal Surface	Collapsing Per Sq. In. of External Surface	External Diameter	Thickness	Bursting Per Sq. In. of Internal Surface	Collapsing Per Sq. In. of External Surface
Ins.	In.	Lbs.	Lbs.	Ins.	In.	Lbs.	Lbs.
1.25	.083	7700	6500	3.25	.12	4000	2700
1.375	.083	6900	5800	3.5	.134	4200	2700
1.5	.083	6200	5200	3.75	.134	3900	2400
1.625	.083	5700	4700	4.	.134	3600	2100
1.75	.083	5300	4300	4.25	.134	3400	1900
1.875	.083	4900	4000	4.5	.134	3200	1700
2.	.083	4500	3700	4.75	.134	3000	1600
2.125	.095	4900	3800	5.	.134	2800	1400
2.25	.095	4600	3600	5.25	.148	3000	1400
2.5	.109	4800	3600	5.5	.148	2800	1200
2.75	.109	4300	3100	5.75	.148	2700	1100
3.	.12	4400	3000	6.	.148	2600	1000

It has been ascertained by experiment that resistance of thin metal plates to a force tending to crush or to crumple them varies directly as a certain power (x) of their thickness.

Hence, *Value* of a tube, etc., to resist collapse is as $\frac{P}{tx}$, *t representing thickness of metal in inches, and* P *total pressure in pounds per square inch.*

To Compute Collapsing Pressure Upon a Flue or Tube (Wrought Iron)

Mean of product of $P' \, l \, d$ in several experiments where metal was of a uniform thickness of .043 inch is 850, for a thickness of .125 inch 9140, etc.; and mean of value of x for all thicknesses is $^{2.19}$.

P′ *representing pressure to which tube is subjected in pounds per square inch, l length of tube in feet, and d diameter in inches.*

By taking $^{2.19}$ for index of t, this formula becomes $\frac{t^{2.19}}{l\,d} V = P'$, *collapsing pressure*, which is general formula for computing strength of wrought iron short flues and tubes subjected to external pressure—that is, provided their length is not less than 1.5 feet, and not greater than 10 feet.

V varies somewhat with length of flues and tubes, and is taken by Fairbairn at 806 300.

Hence,

$$\frac{t^{2.19}}{l\,d} \times 806\,300 = P', \text{ and } \sqrt[2.19]{\frac{l\,d\,P'}{806\,300}} = t, \text{ or } \frac{l\,d\,P'}{806\,300} = t^{2.19}.$$

Flues or tubes subjected to internal pressure or bursting have much greater resistance than when subjected to external pressure or collapsing; in some cases, where lengths of collapsed tubes were 25 feet, difference was about 6.2 times.

Difference, however, between these strains cannot be determined as a rule, for reason that resistance to internal pressure is inversely as diameter of flue or tube alone, without regard to its length; whereas, with resistance to collapse, stress is inversely as product of diameter and length.

STANDARD HEADS FOR BOILER RIVETS

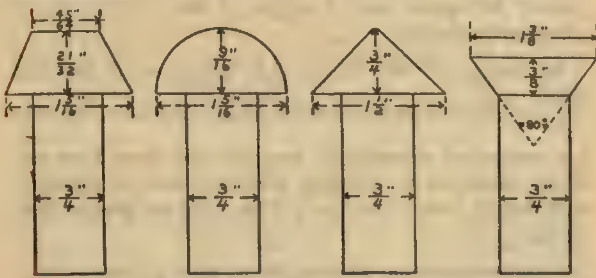
Formulae for Finding Dimensions

Cone Head.—Least diameter, $\frac{15}{16}$ times diameter of rivet shank. Greatest diameter, $1\frac{3}{4}$ times diameter of rivet shank. Height, $\frac{7}{8}$ times diameter of rivet shank.

Button Head.—Diameter, $1\frac{3}{4}$ times diameter of rivet shank. Height, $\frac{3}{4}$ times diameter of rivet shank.

Steeple Head.—Diameter, 2 times diameter of rivet shank. Height, equal to diameter of rivet shank.

Countersunk.—Height, $\frac{1}{2}$ times diameter of rivet shank. 80 degrees taper.



Cone **Button** **Steeple** **Countersunk**

Standard Specification for Boiler Rivets

ADOPTED BY

American Boiler Manufacturers' Association

Philadelphia, Pa., August, 1897
St. Louis, Mo., October, 1898

STEEL

Quality—Physical. Rivets to be of best quality Open Hearth Steel. Tensile Strength, 55,000 to 62,000 pounds. Elongation 30 per cent. in 8 inches; Elastic Limit, at least one-half the Ultimate Strength.

Quality—Analytical. Phosphorus, not over .03; Sulphur, not over .025.

TESTS

Rivets should be tested both hot and cold by driving down on an anvil with the head in a die; by nicking and bending and by bending back on themselves; all without developing cracks or flaws. The heads of the rivets to be of equal strength with the shanks, etc. [See book of Proceedings, A. B. M. Association, 1898.]

STRENGTH OF RIVETS

(TRAUTWINE)

The diameter of a rivet in inches to resist safely a given single shearing force is found by using the formula—

Diameter in inches =

$$\sqrt{\frac{\text{shearing force} \times \text{coef. of safety}}{\text{ultimate shearing strength per sq. in.} \times .7854}}$$

If the rivet is to be double sheared, first multiply only half the shearing force by the coefficient of safety and proceed as before; or, near enough for practice, multiply the diameter in single shear by the decimal .7

Table of Ultimate Single Shearing Strength of Rivets

(ORIGINAL)

Diameter in Fractions	Diameter in Decimals	40000 Pounds Per Square Inch	45000 Pounds Per Square Inch
$\frac{1}{8}$	.125	490	552
$\frac{3}{16}$	.187	1104	1242
$\frac{1}{4}$	.250	1963	2209
$\frac{5}{16}$	.312	3068	3452
$\frac{3}{8}$	.375	4418	4970
$\frac{7}{16}$	.437	6013	6765
$\frac{1}{2}$	.500	7854	8836
$\frac{9}{16}$	.562	9940	11183
$\frac{5}{8}$	.625	12272	13806
$\frac{11}{16}$	.687	14848	16705
$\frac{3}{4}$	.750	17671	19880
$\frac{13}{16}$	.812	20739	23332
$\frac{7}{8}$	.875	24052	27060
$\frac{15}{16}$	.937	27611	31064
1	1.000	31416	35343
$1\frac{1}{16}$	1.062	35465	39899
$1\frac{1}{8}$	1.125	39760	44731
$1\frac{3}{16}$	1.187	44300	49838
$1\frac{1}{4}$	1.250	49088	55224
$1\frac{5}{16}$	1.312	54120	60885
$1\frac{3}{8}$	1.375	59396	66820
$1\frac{7}{16}$	1.437	64920	73035
$1\frac{1}{2}$	1.500	70684	79519

RIVETING

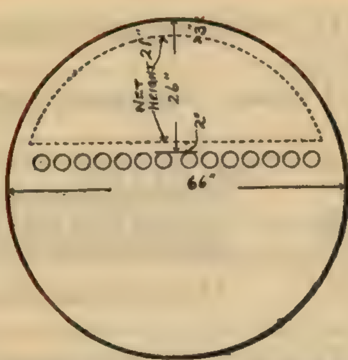
The following table gives the proportions of rivets adopted in some of the best establishments in the United States:

Thickness of Plate, ...	$\frac{1}{4}''$	$\frac{5}{16}''$	$\frac{3}{8}''$	$\frac{7}{16}''$	$\frac{1}{2}''$
Diameter of Rivet, ...	$\frac{5}{8}''$	$\frac{11}{16}''$	$\frac{3}{4}''$	$\frac{13}{16}''$	$\frac{7}{8}''$
Diameter of Rivet-hole, . .	$\frac{11}{16}''$	$\frac{3}{4}''$	$\frac{13}{16}''$	$\frac{7}{8}''$	$\frac{15}{16}''$
Pitch-single Riveting, . .	$2''$	$2\frac{1}{16}''$	$2\frac{1}{8}''$	$2\frac{3}{16}''$	$2\frac{1}{4}''$
Pitch-double Riveting, . .	$3''$	$3\frac{1}{8}''$	$3\frac{1}{4}''$	$3\frac{3}{8}''$	$3\frac{1}{2}''$
Strength of Single Riveted Joint, ...	.59	.55	.52	.50	.49
Strength of Double Riveted Joint, ...	.77	.72	.68	.65	.63

Plates more than ½ inch in thickness should never be joined with lap joints. When it is necessary to use them a butt joint with double butt straps should always be used. In recommending the above proportions we assume that the workmanship is fair.

HUSTON BRACES FOR STANDARD BOILERS

Diameter of Boiler	100 # W. P.					125 # W. P.					150 # W. P.				
	Huston Braces		Stay Rods			Huston Braces		Stay Rods			Huston Braces		Stay Rods		
	No.	Size	No.	Diam.	Diam. End	No.	Size	No.	Diam.	Diam. End	No.	Size	No.	Diam.	Diam. End
30	. .	. . . .	4	3/4	7/8	. . . .	. . . .	4	3/4	7/8	. . . .	. . . .	5	3/4	7/8
30	. .	. . . .	4	3/4	7/8	. . . .	. . . .	4	3/4	7/8	. . . .	. . . .	5	3/4	7/8
36	. .	. . . .	6	3/4	7/8	. . . .	. . . .	6	3/4	7/8	. . . .	. . . .	8	3/4	7/8
36	. .	. . . .	6	3/4	7/8	. . . .	. . . .	6	3/4	7/8	. . . .	. . . .	8	3/4	7/8
42	10	3 x 3/8	. .	. . . .	. . . .	10	3 x 7/16	. .	. . . .	. . . .	10	3 1/4 x 1/2	. .	. . . .	. . . .
42	10	3 x 3/8	. .	. . . .	. . . .	10	3 x 7/16	. .	. . . .	. . . .	10	3 1/4 x 1/2	. .	. . . .	. . . .
44	10	3 x 3/8	. .	. . . .	. . . .	10	3 x 1/2	. .	. . . .	. . . .	10	3 1/4 x 1/2	2	3/4	7/8
44	10	3 x 3/8	. .	. . . .	. . . .	10	3 x 1/2	. .	. . . .	. . . .	10	3 1/4 x 1/2	2	3/4	7/8
44	10	3 x 3/8	. .	. . . .	. . . .	10	3 x 1/2	. .	. . . .	. . . .	10	3 1/4 x 1/2	2	3/4	7/8
48	10	3 x 7/16	. .	. . . .	. . . .	10	3 1/4 x 1/2	1	3/4	7/8	14	3 1/4 x 1/2	1	1 1/8	1 3/8
48	10	3 x 7/16	. .	. . . .	. . . .	10	3 1/4 x 1/2	1	3/4	7/8	14	3 1/4 x 1/2	1	1 1/8	1 3/8
54	14	3 x 3/8	. .	. . . .	. . . .	14	3 x 1/2	2	3/4	7/8	14	3 1/4 x 1/2	2	3/4	7/8
54	14	3 x 3/8	. .	. . . .	. . . .	14	3 x 1/2	2	3/4	7/8	14	3 1/4 x 1/2	2	3/4	7/8
54	14	3 x 3/8	. .	. . . .	. . . .	14	3 x 1/2	2	3/4	7/8	14	3 1/4 x 1/2	2	3/4	7/8
60	14	3 x 7/16	. .	. . . .	. . . .	14	3 1/4 x 1/2	1	1 1/8	1 3/8	18	3 1/4 x 1/2	1	1 1/8	1 3/8
60	14	3 x 7/16	. .	. . . .	. . . .	14	3 1/4 x 1/2	1	1 1/8	1 3/8	18	3 1/4 x 1/2	1	1 1/8	1 3/8
60	14	3 x 7/16	3	1 1/8	1 3/8	14	3 1/4 x 1/2	4	1 1/4	1 5/8	18	3 1/4 x 1/2	5	1 1/4	1 5/8
66	18	3 x 7/16	3	1 1/4	1 5/8	18	3 1/4 x 1/2	4	1 1/4	1 5/8	22	3 1/4 x 1/2	4	1 1/4	1 5/8
66	18	3 x 7/16	3	1 1/4	1 5/8	18	3 1/4 x 1/2	4	1 1/4	1 5/8	22	3 1/4 x 1/2	4	1 1/4	1 5/8
66	18	3 x 7/16	3	1 1/4	1 5/8	18	3 1/4 x 1/2	4	1 1/4	1 5/8	22	3 1/4 x 1/2	4	1 1/4	1 5/8
72	22	3 x 7/16	4	1 1/4	1 5/8	22	3 1/4 x 1/2	5	1 1/4	1 5/8	30	3 1/4 x 1/2	6	1 1/4	1 5/8
72	22	3 x 7/16	4	1 1/4	1 5/8	22	3 1/4 x 1/2	5	1 1/4	1 5/8	30	3 1/4 x 1/2	6	1 1/4	1 5/8
78	26	3 x 7/16	3	1 1/4	1 5/8	26	3 1/4 x 1/2	4	1 1/4	1 5/8	30	3 1/4 x 1/2	. .	. . . .	. . . .
84	34	3 x 7/16	3	1 1/4	1 5/8	34	3 1/4 x 1/2	4	1 1/4	1 5/8	42	3 1/4 x 1/2	. .	. . . .	. . . .



Illustrating the "Area to be Braced," Enclosed by Dotted Lines

Area of Circular Segments above Tubes in Horizontal Boilers Needing Bracing

AREAS IN SQUARE INCHES

Net Height, Inches	Diameter of Boilers								
	72"	66"	60"	54"	50"	48"	46"	42"	36"
30	1515	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
29	1447	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
28	1380	1295	. . .	. . .	. . .	. . .	. . .	. . .	. . .
27	1316	1234	. . .	. . .	. . .	. . .	. . .	. . .	. . .
26	1252	1173	1093	. . .	. . .	. . .	. . .	. . .	. . .
25	1183	1114	1037	. . .	. . .	. . .	. . .	. . .	. . .
24	1126	1056	982	. . .	. . .	. . .	. . .	. . .	. . .
23	1061	996	930	. . .	. . .	. . .	. . .	. . .	. . .
22	997	937	875	808	. . .	. . .	. . .	. . .	. . .
21	936	880	822	761	. . .	. . .	. . .	. . .	. . .
20	875	824	770	714	673	650	. . .	. . .	. . .
19	816	768	718	667	629	609	. . .	. . .	. . .
18	758	713	667	620	585	568	548	. . .	. . .
17	698	659	618	573	542	526	509	. . .	. . .
16	639	606	567	527	500	485	470	435	. . .
15	584	553	519	481	458	444	430	401	. . .
14	529	500	471	435	416	404	392	366	324
13	477	451	424	394	376	365	354	331	294
12	425	402	378	354	336	327	317	297	264
11	373	356	335	313	297	290	282	263	235
10	327	311	292	273	259	253	246	231	206
9	278	267	251	236	224	218	212	199	179
8	235	223	211	199	189	183	179	168	152
7	195	185	175	165	156	152	148	140	126
6	155	147	139	131	124	122	118	112	101

Illustrating Bracing and Flue Spacing

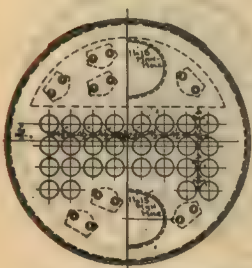
HUSTON BRACES

42 Inches Diameter
42—2½ Inch Tubes

42 Inches Diameter
24—3 Inch Tubes

44 Inches Diameter
34—3 Inch Tubes

48 Inches Diameter
42—3 Inch Tubes

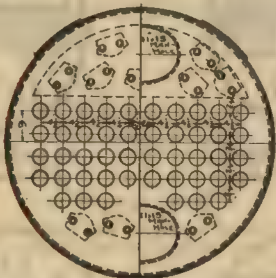


48 Inches Diameter
28—3½ Inch Tubes

48 Inches Diameter
26—4 Inch Tubes

Illustrating Bracing and Flue Spacing—Continued

HUSTON BRACES



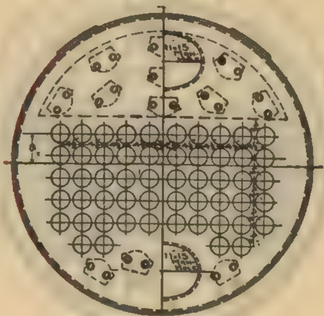
54 Inches Diameter
46—3 Inch Tubes

54 Inches Diameter
44—3½ Inch Tubes

54 Inches Diameter
36—4 Inch Tubes

Illustrating Bracing and Flue Spacing—Continued

HUSTON BRACES

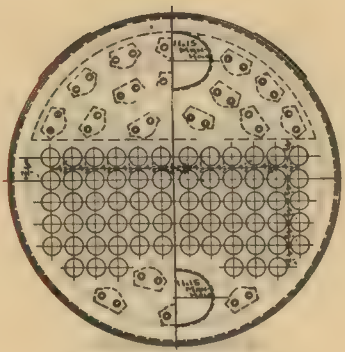


60 Inches Diameter
54—3½ Inch Tubes

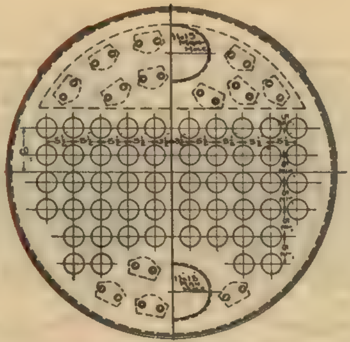
60 Inches Diameter
46—4 Inch Tubes

Illustrating Bracing and Flue Spacing—Continued

HUSTON BRACES



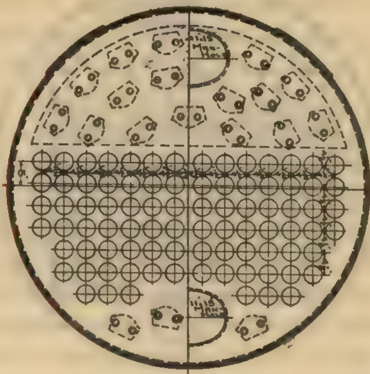
66 Inches Diameter
66—3½ Inch Tubes



66 Inches Diameter
52—4 Inch Tubes

Illustrating Bracing and Flue Spacing—Continued

HUSTON BRACES

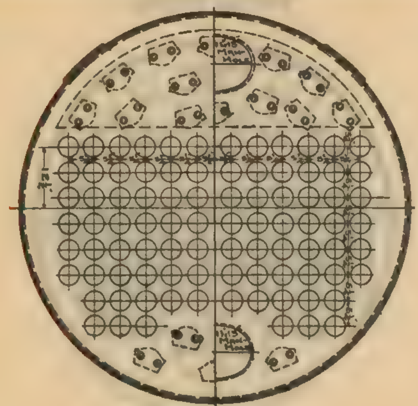


72 Inches Diameter
86—3½ Inch Tubes

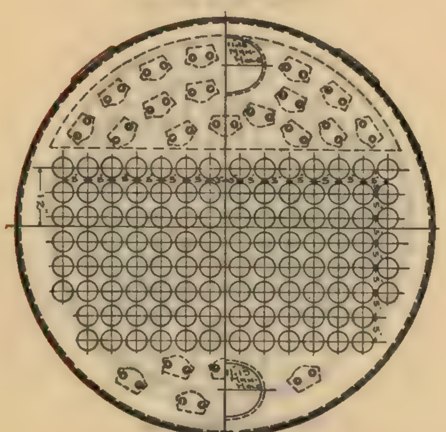
72 Inches Diameter
76—4 Inch Tubes

Illustrating Bracing and Flue Spacing—Concluded

HUSTON BRACES



78 Inches Diameter
88—4 Inch Tubes



84 Inches Diameter
108—4 Inch Tubes

CHIMNEYS

Chimneys are required for two purposes, (1) to carry off noxious gases; (2) to produce a draught, and so facilitate combustion. The first requires size, the second, height.

Each pound of coal burned yields from 13 to 30 pounds of gas, the volume of which varies with the temperature.

The weight of gas to be carried off by a chimney in a given time depends upon three things: size of chimney, velocity of flow, and density of gas. But as the density decreases directly as the absolute temperature, while the velocity increases with a given height, nearly as the square root of the temperature, it follows that there is a temperature at which the weight of gas delivered is a maximum. This is about 550 degrees above the surrounding air. Temperature, however, makes so little difference that at 550 degrees above, the quantity is only four per cent. greater than at 300 degrees. Therefore, height and area are the only elements necessary to consider in an ordinary chimney.

A round chimney is better than square, and a straight flue better than a tapering, though it may be either larger or smaller at top without detriment.

The effective area of a chimney for a given power varies inversely as the square root of the height. The actual area, in practice, should be greater because of retardation of velocity due to friction against the walls. On the basis that this is equal to a layer of air 2 inches thick over the whole interior surface, and that a com-

mercial horse power requires the consumption on an average of 5 pounds of coal per hour, we have the following formulæ :

$$E = \frac{0.3\,H}{\sqrt{h}} = A - 0.6\sqrt{A} \quad \ldots\ldots\ldots \quad 1$$

$$H = 3.33\,E\sqrt{h} \quad \ldots\ldots\ldots \quad 2$$

$$S = 12\sqrt{E} + 4'' \quad \ldots\ldots\ldots \quad 3$$

$$D = 13.54\sqrt{E} + 4'' \quad \ldots\ldots\ldots \quad 4$$

$$h = \left(\frac{0.3\,H}{E}\right)^2 \quad \ldots\ldots\ldots \quad 5$$

in which

H equals horse power.
h " height of chimney in feet.
E " effective area.
A " actual area in square feet.
S " side of square chimney.
D " diameter of round chimney, in inches.

The table on page 109 is calculated by means of these formulæ.

The external diameter of a brick chimney at the base should be one-tenth the height, unless it be supported by some other structure.

The "batter" or taper of a chimney should be from $\frac{1}{16}$ to $\frac{1}{4}$ inch to the foot on each side.

Thickness of brickwork : One brick (8 or 9 inches), for 25 feet from the top, increasing half a brick (4 or $4\frac{1}{2}$ inches) for each 25 feet from top downward.

If the inside diameter exceed 5 feet, the top length should be one and a half bricks, and if under 3 feet, it may be half a brick for 10 feet.

In many places, steel stacks are preferred to brick chimneys. Their efficiency for the same dimensions is somewhat higher, because there is no infiltration of air as through brickwork.

These chimney stacks, when properly constructed, are stronger than brick chimneys of the same size. There are in general use three characters of steel plate chimneys, the first being the ordinary smoke stack, which is guyed with outstanding guys; the second has a bell-shaped bottom and is erected upon heavy foundations with the metal of such thickness as not to require any guying; the third is made similar in construction to the second, excepting that it is lined clear to the top with brick. A so-called self-supporting smoke stack, lined clear to the top with brick, will cost somewhat less than a brick chimney of the same dimensions. Steel stacks of the self-supporting character should be well secured to the foundation with heavy bolts, extending either through a heavy cast-iron base plate covering the foundation or through special holding-down lugs placed upon the stack. For this character of stack it is also recommended that the flue from the boilers enter the stack under the base-plate, so that there will be no opening cut through the steel shell. They should also be well painted to prevent rusting, for which purpose a ladder extending from the base to the top is usually placed upon it. When steel stacks are braced with outstanding guys to surrounding

objects, these guys are generally attached at about two-thirds the height of the stack, spreading laterally, at least an equal distance, and are composed of heavy wire, galvanized wire rope, or rods. Each brace should have an area in square inches equal to one one-thousandth of the exposed area of the stack (diameter times the height) in feet.

Stability, or power to withstand the overturning force of the highest winds, requires a proportionate relation between the weight, height, breadth of base, and exposed area of the chimney. This relation is expressed in the equation—

$$C \frac{d\,h^2}{b} = W$$

in which

d equals the average breadth of the shaft, in feet.
h " its height, in feet.
b " the breadth of base, in feet.
W " the weight of chimney, in pounds.
C, a coefficient of wind pressure per square foot of area.

This varies with the cross-section of the chimney, and equals 56 for a square, 35 for an octagon, and 28 for a round chimney. Thus a square chimney of average breadth of 8 feet, 10 feet wide at base and 100 feet high, would require to weigh $56 \times 8 \times 100 \times 10$, or 448,000 pounds, to withstand any gale likely to be experienced. Brickwork weighs from 100 to 130 pounds per cubic foot, hence such a chimney must average 13 inches thick to be safe. A round stack would weigh half as much or have less base.

Height of Chimneys and Commercial Horse Power of Boilers

(From Kent's Handbook)

Diameter in Inches	50 Feet	60 Feet	70 Feet	80 Feet	90 Feet	100 Feet	110 Feet	125 Feet	150 Feet	175 Feet	200 Feet	225 Feet	250 Feet	300 Feet	Side of Square Inches	Effective Area, Sq. Ft.	Actual Area, Sq. Ft.
	H. P.	H. P.	H. P.	H. P.	H. P.	H. P.	H. P.	H. P.	H. P.	H. P.	H. P.	H. P.	H. P.	H. P.			
18	23	25	27	29	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	16	0.97	1.77
21	35	38	41	44	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	19	1.47	2.41
24	49	54	58	62	66	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	22	2.08	3.14
27	65	72	78	83	88	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	24	2.78	3.98
30	84	92	100	107	113	119	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	27	3.58	4.91
33	. . .	115	125	133	141	149	156	. . .	. . .	. . .	. . .	. . .	. . .	. . .	30	4.48	5.94
36	. . .	141	152	163	173	182	191	204	. . .	. . .	. . .	. . .	. . .	. . .	32	5.47	7.07
39	. . .	. . .	183	196	208	219	229	245	268	. . .	. . .	. . .	. . .	. . .	35	6.57	8.30
42	. . .	. . .	216	231	245	258	271	289	316	342	. . .	. . .	. . .	. . .	38	7.76	9.62
48	. . .	. . .	. . .	311	330	348	365	389	426	460	492	. . .	. . .	. . .	43	10.44	12.57
54	. . .	. . .	. . .	. . .	427	449	472	503	551	595	636	675	. . .	. . .	48	13.51	15.90
60	. . .	. . .	. . .	. . .	536	565	593	632	692	748	800	848	894	. . .	54	16.98	19.64
66	. . .	. . .	. . .	. . .	. . .	694	728	776	849	918	981	1040	1097	1201	59	20.83	23.76
72	. . .	. . .	. . .	. . .	. . .	835	876	934	1023	1105	1181	1253	1320	1447	64	25.08	28.27
78	. . .	. . .	. . .	. . .	. . .	. . .	1038	1107	1212	1310	1400	1485	1565	1715	70	29.73	33.18
84	. . .	. . .	. . .	. . .	. . .	. . .	1214	1294	1418	1531	1637	1736	1830	2005	75	34.76	38.48
90	. . .	. . .	. . .	. . .	. . .	. . .	. . .	1496	1639	1770	1893	2008	2116	2318	80	40.19	44.18
96	. . .	. . .	. . .	. . .	. . .	. . .	. . .	1712	1876	2027	2167	2298	2423	2654	86	46.01	50.27
102	. . .	. . .	. . .	. . .	. . .	. . .	. . .	1944	2130	2300	2459	2609	2750	3012	91	52.23	56.75
108	. . .	. . .	. . .	. . .	. . .	. . .	. . .	2090	2399	2592	2771	2939	3098	3393	96	58.83	63.62
114	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	2685	2900	3100	3288	3466	3797	101	65.83	70.88
120	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	2986	3226	3448	3657	3855	4223	107	73.22	78.54
132	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	3637	3929	4200	4455	4696	5144	117	89.18	95.03
144	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	4352	4701	5026	5331	5618	6155	128	106.72	113.10

FORCE OF THE WIND

Miles per Hour	Feet per Minute	Feet per Second	Force, in lbs., per Square Foot	Description
1	88	1.47	0.005	Hardly perceptible.
2	176	2.93	0.02	Just perceptible.
3	264	4.4	0.044	
4	352	5.87	0.079	Gentle breeze.
5	440	7.33	0.123	
10	880	14.67	0.492	Pleasant breeze.
15	1320	22.00	1.107	
20	1760	29.34	1.970	Brisk gale.
25	2200	36.66	3.067	
30	2640	44.01	4.429	High wind.
35	3080	51.3	6.027	
40	3520	58.6	7.87	Very high wind.
45	3960	66.01	9.91	
50	4400	73.35	12.304	Storm.
60	5280	88.02	17.733	Great storm.
70	6160	102.7	24.153	
80	7040	117.3	31.490	Hurricane.
100	8800	146.6	49.200	

FUEL

The most important fuel in use for boiler purposes at the present time is coal. Wood is used, as a rule, only where it is very abundant, or where coal cannot be readily obtained. In some locations where gas and oil can be favorably procured, these can be used for fuel. Frequently the waste gases from furnaces of various kinds is made use of.

Some degree of success has been reached by first converting coal into gas, and then burning the gas under the boilers, but as yet the advantages do not seem to be sufficient to induce extended use of this method, so that, generally speaking, either bituminous or anthracite coal is used for boilers. In the United States a long ton of coal is 2240 pounds, and a short one 2000 pounds.

From 70 to 80 pounds of bituminous coal is counted a bushel, depending upon the locality. According to measurements made with Wilkes-Barre Anthracite coal from the Wyoming Valley, 28.8 cubic feet of lump, 30.3 cubic feet of broken, 30.8 cubic feet of egg, 31.1 cubic feet of stove, 31.9 cubic feet of chestnut, or 32.8 cubic feet of pea, make one net ton of 2000 pounds.—*Kent.*

36 cubic feet of "Run of Mine" bituminous coal will weigh 2000 pounds. The practical effect of exposing coal to the weather, while sometimes increasing its absolute weight, is to diminish the quantity of carbon and to reduce its calorific value.—*Kent.*

PETROLEUM COMPARED WITH COAL AS FUEL

Comparison of petroleum with coal as a heating agent, according to comparative tests reported to the Engineers' Club of Philadelphia, showed—

	Pounds Water from and at 212° Fahr.
1 pound Anthracite Coal Evaporated, . . .	9.70
1 pound Bituminous Coal Evaporated, . . .	10.14
1 pound Fuel Oil, 36 degrees gravity, . . .	16.48
1 cubic foot Gas, 20 c. p., ...	1.28

showing that while petroleum has theoretically only about 45 per cent. more heat-units (21,000) than bituminous coal (14,500), the practical evaporative efficiency is about 60 per cent. greater.—*Kent.*

HEATING EFFICIENCY OF DIFFERENT KINDS OF WOOD

One cord dry hickory or hard maple, 4500 pounds, equals 1800 to 2000 pounds of coal.

One cord white oak, 3850 pounds, equals 1500 to 1715 pounds of coal.

One cord beech, red and black oak, 3250 pounds, equals 1300 to 1450 pounds of coal.

One cord poplar, chestnut, and elm, 2350 pounds, equals 940 to 1050 pounds of coal.

One cord of average soft pine, 2000 pounds, equals 800 to 925 pounds of coal; *i. e.*, on an average 2¼ pounds of dry wood equals 1 pound of dry coal for heat efficiency.—*Kent.*

CLASSIFICATION OF COALS, AS ANTHRACITE, BITUMINOUS, ETC.

(Kent)

Carbon ratio meaning ratio of fixed carbon to volatile or hydrocarbon.

	Carbon Ratio	Fixed Carbon, Per cent.	Volatile Hydrocarbon, Per cent.
1. Hard, dry anthracite,	100 to 12	100 to 92.31	0 to 7.69
2. Semi-anthracite, . .	12 to 7	92.31 to 87.5	7.69 to 12.5
3. Semi-bituminous, .	7 to 3	87.5 to 75	12.5 to 25
4. Bituminous, ...	3 to 0	75 to 0	25 to 100

Approximate Expansion of Solids by Heat, and Their Melting Points by Fahrenheit's Thermometer

	For 1 Degree		For 180 Degrees		Melting Point in Degrees
	1 part in	⅛ inch in Feet	1 part in	⅛ inch in Feet	
Fire-brick, . .	365220	3804	2029	21.14	. . . .
Granite, from	187560	1954	1042	10.85	. . . .
Granite, to	228060	2375	1267	13.20	. . . .
Glass Rod, . .	221400	2306	1230	12.81	2377
Platinum, .	208800	2175	1160	12.08	3227
Marble, . . .	173000	1802	961	10.00	. . . .
Antimony, . .	166500	1722	925	9.63	955
Cast Iron, . .	162000	1688	900	9.38	1920 to 2280
Slate, ...	173000	1802	961	10.00	. . . .
Steel, . . .	151200	1575	840	8.75	2370
Iron, rolled, .	149940	1562	833	8.68	2700 to 2912
Iron, soft, forg'd	147420	1536	819	8.53	3500
Bismuth, . .	129600	1350	720	7.50	506
Copper, average	104400	1088	580	6.04	2000
Sandstone, .	103320	1076	574	5.98	. . . .
Brass, average	97740	1018	543	5.66	1873
Silver, ...	95040	990	528	5 50	1861
Tin, . average	87840	915	488	5.08	444
Lead, average	63180	658	351	3.66	612
Pewter, . .	78840	821	438	4.56	. . . .
Zinc, ...	61920	645	344	3.58	680 to 772

Heat of a common wood fire variously estimated from 800° to 1140°. That of a charcoal one about 2200°; coal about 2400°.

Each 12° to 15° of expansion of wrought iron is equivalent to about 1 ton tension per square inch of section; varying with quality of iron.

A 10-inch iron steam pipe, 105 feet long, expanded 2½ inches after steam was turned into it at 125 lbs. pressure. An 18-inch steam pipe, 210 feet long, expanded 4¾ inches after steam was turned on.

COAL

Coal, as a fuel, is rated according to the quantities and calorific value of the combustible elements it contains. The most important of these are carbon and hydrogen; the combustion of 1 pound of hydrogen producing 62,000 B. T. U., and of 1 pound of carbon, 14,500 B. T. U. Hence, although several coals may have the same percentage of combustible and ash, it does not follow that their calorific value will be identical, for this depends upon the amount of hydrogen and carbon they contain.

The value of fuel may be determined by chemical analysis, by which the proportion of the elements that it contains is found, and by calorimetric test, although the latter is considered the more reliable method of the two.

In practice, no fuel gives its full theoretical evaporation value, owing, first, to the losses that result from radiation and conduction of heat from the boiler setting, which in some cases have been found as high as 24 per cent.; second, to the carelessness or ignorance of the fireman in improperly firing; third, to the frequent admission of cold air into the furnace, either through the firing doors or through cracks in the setting; fourth, to errors in the design and construction of the boiler itself. An efficiency of 80 per cent. is seldom obtained, and only in the best boilers, while the average is about 65 per cent.,—the better the boiler, the higher the efficiency.

The following is a table that has been calculated by D. S. JACOBUS, M. E., from data obtained by experiment, which shows the relative saving of fuel of the various methods for supplying feed water to boilers:

METHOD OF SUPPLYING FEED WATER TO BOILER Temperature of feed water as delivered to the pump or to the injector, 60° Fahr. Rate of evaporation of boiler, 10 pounds of water per pound of coal from and at 212° Fahr.	Relative amount of coal required per unit of time, the amount for a direct acting pump, feeding water at 60°, without a heater, being taken as unity.	Saving of fuel over the amount required when the boiler is fed by a direct acting pump without heater.
Direct acting pump, feeding water at 60°, without a heater, ...	1.000	.0
Injector feeding water at 150°, without a heater, .	.985	1.5 per cent.
Injector feeding through a heater in which the water is heated from 150° to 200°, ...	.938	6.2 "
Direct acting pump feeding water through a heater, in which it is heated from 60° to 200°,	.879	12.1 "
Geared pump, run from the engine, feeding water through a heater, in which it is heated from 60° to 200°, ...	.868	13.2 "

Table showing the saving of fuel in per cent. by heating the feed water, steam being taken at 60 pounds.

Initial Temp. of Water	Final Temperature of Feed Water						
	120	140	160	180	200	250	300
32°	7.50	9.20	10.90	12.36	14.30	19.03	22.90
35	7.25	8.96	10.66	12.09	14.09	18.34	22.60
40	6.85	8.57	10.28	12.00	13.71	17.99	22.27
45	6.45	8.17	9.90	11.61	13.34	17.64	21.94
50	6.05	7.71	9.50	11.23	13.00	17.28	21.61
55	5.64	7.37	9.06	10.85	12.60	16.93	21.27
60	5.23	6.97	8.72	10.46	12.20	16.58	20.92
65	4.82	6.56	8.32	10.07	11.82	16.20	20.58
70	4.40	6.15	7.91	9.68	11.43	15.83	20.23
75	3.98	5.74	7.50	9.28	11.04	15.46	19.88
80	3.55	5.32	7.09	8.87	10.65	15.08	19.52
85	3.12	4.60	6.63	8.46	10.25	14.70	19.17
90	2.68	4.47	6.26	8.06	9.85	14.32	18.81
95	2.24	4.04	5.84	7.65	9.44	13.94	18.44
100	1.80	3.61	5.42	7.23	9.03	13.55	18.07
110	.90	2.73	4.55	6.38	8.20	12.76	17.28
120	.00	1.84	3.67	5.52	7.36	11.95	16.49
130	. . .	.92	2.77	4.64	6.99	11.14	15.24
140	. . .	.00	1.87	3.75	5.62	10.31	14.99
150	. . .	. . .	.94	2.83	4.72	9 46	14.18
160	. . .	. . .	.00	1.91	3.82	8.59	13.37
170	. . .	. . .	. . .	.96	2.89	7.71	12.54
180	. . .	. . .	. . .	.00	1.96	6.81	11.70
190	. . .	. . .	. . .	. . .	.90	5.90	10.82
200	. . .	. . .	. . .	. . .	.00	4.85	9.93

The most economical means of heating feed water above 212 degrees is to utilize the furnace gases after they have passed the boiler.

HEAT, STEAM, WATER

HEAT

Heat is the form in which we receive most of the sun-energy. In the various fuels it exists in a potential form, requiring combustion, *i. e.*, combustion of the active elements of the fuel with the oxygen of the air, to reappear in its active form.

Heat, as a form of energy, is subject to the general laws which govern every form of energy, and control all matter in motion, whether that motion be molecular or the movement of masses.

Quantities of heat are measured in English units, by what is termed the British thermal unit, or for brevity, B. T. U. The B. T. U. is the quantity of heat required to raise 1 pound of pure water from a temperature of 39° Fahr. to 40° Fahr., and has an equivalent in mechanical units of power. This is simply called a heat-unit or designated by h. u. The mechanical unit of power is the foot-pound, or the power required to raise 1 pound 1 foot high. Joule's experiments show 772 foot-pounds to be equivalent to 1 B. T. U. (Later investigations give higher figures, and the probable average is now considered to be 778.) According to Watt, 33,000 foot-pounds per minute was called a horse power, and is used as such to-day, it being the unit for large power.

The electrical unit of power is the watt, which is the product of 1 ampère by 1 volt; 746 watts are equivalent to 1 horse power or 33,000 foot-pounds. Hence the watt is an equivalent in heat-units also.

Equivalents of Power and Heat

B. T. U.	FT. LBS.	WATTS.
1 =	778 =	17.59
42.42 =	33000 =	746 = 1 h. p.

A French "calorie" is the heat required to raise one kilogramme of water 1° C., and is equal to 3.96832 B. T. U.

The elements necessary to generate steam are fuel, heat, atmosphere, and water. The chief constituents of fuel are carbon and hydrogen, and the union of oxygen with these elements is termed combustion. Heat and mechanical power are mutually convertible forces. The force of the heat that raises 1 pound of water 1° Fahr. will lift a weight of 778 pounds 1 foot high. The power of a weight of 778 pounds descending 1 foot, if applied to a small paddle-wheel turning 1 pound of water, will, by friction, raise the temperature of the water 1° Fahr.

A heat-unit is the amount of heat that raises a pound of water 1° Fahr., or that lifts a weight of 778 pounds 1 foot high. The mechanical equivalent of a heat-unit is the power of a weight of 778 pounds descending 1 foot, or of a 1-pound weight descending 778 feet. Hence,

778 foot-pounds = 1 heat-unit.
1 heat-unit = 778 foot-pounds.

Sensible heat is that which is sensible to the touch or measurable by a thermometer. The mechanical equivalent of heat is the amount of work performed by the conversion of 1 unit of heat into work, and the *mechanical theory* of heat is based on the assumption that heat and work are mutually convertible.

Latent heat is that which is insensible to the touch of our bodies, and is incapable of being detected by a thermometer. That is, a quantity of heat which has disappeared, having been employed in producing some change other than elevation of temperature, and by exactly reversing that change, the quantity of heat which has disappeared is reproduced. For instance, while 1 heat-unit applied to a pound of water will elevate its temperature 1° Fahr., it will require $142\frac{65}{100}$ heat-units to change 1 pound of ice at 32° Fahr. into water at 32° Fahr., or $965\frac{7}{10}$ heat-units to change 1 pound of water at 212° Fahr. into steam at 212° Fahr. Or, if that 1 pound of steam were reduced to the liquid state, simply by compression, without the removal of any of its heat, the temperature of the pound of water would be found to be approximately 212° plus $965\frac{7}{10}°$ equals $1177\frac{7}{10}°$, the $965\frac{7}{10}°$ of latent heat becoming sensible heat again.

Specific Heat (or Heat-absorbing Capacity).—Water has a greater heat-absorbing capacity than any other known substance (hydrogen and bromine excepted), hence it is used as the unit of comparison, and consequently the specific heat of any substance is its ability to absorb heat as compared with an equal weight of water at 62° Fahr.

WATER

Water with a barometer at 30° boils in the open air at sea level at 212° Fahr., and in vacuum at 88° Fahr. The less the pressure of the atmosphere, the lower is the temperature at which water will boil. The pres-

sure of the atmosphere at sea level is 14.7 pounds per square inch, pressing equally and in all directions. This has been ascertained from the following illustration: Because the height of a column of air of one square inch area exactly balances a column of mercury of the same area 30 inches in height, and also a column of water 33.86 feet in height, it follows that a column of air, 30 inches of mercury, and 33.86 feet of water weigh the same; and since the last two weigh the same, respectively 14.7 pounds, per square inch, a full column of air must weigh the same. A cubic foot of water, evaporated under a pressure of one atmosphere, or 15 pounds per square inch, occupies a space of 1700 cubic feet.

Salt water boils at a higher temperature than fresh, owing to its greater density, and because the boiling point of water is increased by any substance that enters into chemical combination with it. The density of water decreases as the temperature increases, since heat destroys cohesion and expands the particles, causing them to occupy greater space. The power of water to hold chemical substances, such as salts of lime, in solution decreases as the temperature increases; from this follows that boilers carrying high pressure of steam form more scale than those working at low temperatures.

The law of expansion by heat and contraction by cold is true as relating to water, with this exception: that, as hot water cools down from the boiling point, it contracts until 39.1° Fahr. is reached; but if it cools down from this point it expands again. In other words, from 32° to 39.1° Fahr. the density of water increases; above the

latter temperature the density diminishes, because water is expanded into a greater space by an increase of temperature. Water has the greatest specific heat of all known substances, except hydrogen, and is, therefore, taken as the standard for all solids and fluids.

WATER AT DIFFERENT TEMPERATURES

There are four notable temperatures for pure water, viz.:

1. Freezing point at sea level, . . . 32° F.
2. Point of maximum density, . . . 39.1° F.
3. British standard for spec. gravity, 62° F.
4. Boiling point at sea level, ... 212° F.

32° F.	Weight	per cu. ft.,		62.418 lb;	per	cu. in.,		.03612 lb
39.1° F.	"	"	"	62.425 "	"	"		.036125 "
62° F.	"	"	"	62.355 "	"	"		.03608 "
212° F.	"	"	"	59.760 "	"	"		.03458 "

A United States standard gallon holds 231 cubic inches and 8⅓ pounds water at 62° F.

A British Imperial gallon holds 277.274 cubic inches and 10 pounds water at 62° F.

Sea water (average) has a specific gravity of 1.028, boils at 213.2° F., and weighs 64 pounds per cubic foot at 62° F.

A pressure of 1 pound per square inch is exerted by a column of water 2.3093 feet, or 27.71 inches high, at 62° F.

In solvent power water has a greater range than any other liquid. For common salt this is nearly constant at all temperatures, while it increases with increase of temperature for others,—magnesium and sodium sulphates, for instance.

Where water contains carbonic acid it dissolves some minerals quite readily, but a boiling temperature causes the disengagement of the carbonic acid in gaseous form

and the deposition of a large part of the minerals thus held in solution.

Lime salts are more soluble in cold than in hot water, and most of them are deposited at 320°, or less. When frozen into ice, or evaporated into steam, water parts with nearly all substances held in solution.

TABLE OF SOLUBILITIES OF SCALE-MAKING MINERALS

Substance	Soluble in Parts of Pure Water at 32° F.	Soluble in Parts of Carbonic Acid Water, Cold	Soluble in Parts of Pure Water at 212° F.	Insoluble in Water at—
Carbonate of Lime, .	62500	150	62500	302° F.
Sulphate of Lime, . .	500	. . .	460	302° F.
Carbonate of Magnesia,	5500	150	9600	. . .
Phosphate of Lime, .	. . .	1333	. . .	212° F.
Oxide of Iron, ...	. . .	. . .	. . .	212° F.
Silica, ...	. . .	Und't'd	. . .	212° F.

The specific heat of water is not constant, but rises in an increasing ratio with the temperature, so that it requires slightly more heat, the higher the temperature, to raise a given quantity of water from one temperature to another. The specific heat of ice and steam are, respectively, .504 and .475, or practically about half that of water.

The following table gives the number of British thermal units in a pound of water at different temperatures. They are reckoned above 32° F., for, strictly speaking, *water* does not exist below 32°, and ice follows another law.

WATER BETWEEN 32 DEGREES AND 212 DEGREES FAHR.

Temperature Fahr.	Heat Units per Pound	Weight, Pounds per Cubic Foot	Temperature Fahr.	Heat Units per Pound	Weight, Pounds per Cubic Foot	Temperature Fahr.	Heat Units per Pound	Weight, Pounds per Cubic Foot	Temperature Fahr.	Heat Units per Pound	Weight, Pounds per Cubic Foot
32°	0.00	62.42	110°	78.00	61.89	145°	113.26	61.28	179°	147.54	60.57
35	3.02	62.42	112	80.00	61.86	146	114.27	61.26	180	148.54	60.55
40	8.06	62.42	113	81.01	61.84	147	115.28	61.24	181	149.55	60.53
45	13.08	62.42	114	82.02	61.83	148	116.29	61.22	182	150.56	60.50
50	18.10	62.41	115	83.02	61.82	149	117.30	61.20	183	151.57	60.48
52	20.11	62.40	116	84.03	61.80	150	118.30	61.18	184	152.58	60.46
54	22.11	62.40	117	85.04	61.78	151	119.31	61.16	185	153.58	60.44
56	24.11	62.39	118	86.05	61.77	152	120.32	61.14	186	154.59	60.41
58	26.12	62.38	119	87.06	61.75	153	121.33	61.12	187	155.60	60.39
60	28.12	62.37	120	88.06	61.74	154	122.34	61.10	188	156.61	60.37
62	30.12	62.36	121	89.07	61.72	155	123.34	61.08	189	157.62	60.34
64	32.12	62.35	122	90.08	61.70	156	124.35	61.06	190	158.62	60.32
66	34.12	62.34	123	91.09	61.68	157	125.36	61.04	191	159.63	60.29
68	36.12	62.33	124	92.10	61.67	158	126.37	61.02	192	160.63	60.27
70	38.11	62.31	125	93.10	61.65	159	127.38	61.00	193	161.64	60.25
72	40.11	62.30	126	94.11	61.63	160	128.38	60.98	194	162.65	60.22
74	42.11	62.28	127	95.12	61.61	161	129.39	60.96	195	163.66	60.20
76	44.11	62.27	128	96.13	61.60	162	130.40	60.94	196	164.66	60.17
78	46.10	62.25	129	97.14	61.58	163	131.41	60.92	197	165.67	60.15
80	48.09	62.23	130	98.14	61.56	164	132.42	60.90	198	166.68	60.12
82	50.08	62.21	131	99.15	61.54	165	133.42	60.87	199	167.69	60.10
84	52.07	62.19	132	100.16	61.52	166	134.43	60.85	200	168.70	60.07
86	54.06	62.17	133	101.17	61.51	167	135.44	60.83	201	169.70	60.05
88	56.05	62.15	134	102.18	61.49	168	136.45	60.81	202	170.71	60.02
90	58.04	62.13	135	103.18	61.47	169	137.46	60.79	203	171.72	60.00
92	60.03	62.11	136	104.19	61.45	170	138.46	60.77	204	172.73	59.97
94	62.02	62.09	137	105.20	61.43	171	139.47	60.75	205	173.74	59.95
96	64.01	62.07	138	106.21	61.41	172	140.48	60.73	206	174.74	59.92
98	66.01	62.05	139	107.22	61.39	173	141.49	60.70	207	175.75	59.89
100	68.01	62.02	140	108.22	61.37	174	142.50	60.68	208	176.76	59.87
102	70.00	62.00	141	109.23	61.36	175	143.50	60.66	209	177.77	59.84
104	72.00	61.97	142	110.24	61.34	176	144.51	60.64	210	178.78	59.82
106	74.00	61.95	143	111.25	61.32	177	145.52	60.62	211	179.78	59.79
108	76.00	61.92	144	112.26	61.30	178	146.53	60.59	212	180.79	59.76

WATER PRESSURE

The pressure of still water in pounds per square inch against the sides of any pipe or vessel of any shape whatever, is due alone to the *head*, or height of the surface of the water above the point considered pressed upon, and is equal to 0.434 pound per square inch for every foot of head. The fluid pressure per square inch is equal in all directions.

To find the total pressure of quiet water against and perpendicular to any surface, whether vertical, horizontal or inclined at any angle, whether it be flat or curved, multiply together the area in square feet of the surface pressed, the vertical depth of its center of gravity below the surface of the water, and the constant 62.5. The product will be the required pressure in pounds. This may be expressed by formula as follows:

$$P = 62.5\ A\ D,$$

in which P = the pressure in pounds of quiescent water on the surface considered.

A = the area pressed upon in square feet, and

D = the vertical depth in feet of center of gravity of surface considered.

Pressures in Pounds per Square Inch in Pipes, Etc., under different Heads of Water

Feet Head	Pressure per Square Inch	Feet Head	Pressure per Square Inch	Feet Head	Pressure per Square Inch	Feet Head	Pressure per Square Inch	Feet Head	Pressure per Square Inch
1	0.43	15	6.49	29	12.55	43	18.62	57	24.69
2	0.86	16	6.93	30	12.99	44	19 05	58	25.12
3	1.30	17	7.36	31	13.42	45	19.49	59	25.55
4	1.73	18	7.79	32	13.86	46	19.92	60	25.99
5	2.16	19	8 22	33	14.29	47	20.35	61	26.42
6	2.59	20	8.66	34	14.72	48	20.79	62	26.85
7	3.03	21	9.09	35	15.16	49	21.22	63	27.29
8	3.46	22	9.53	36	15.59	50	21.65	64	27.72
9	3.89	23	9.96	37	16.02	51	22.09	65	28.15
10	4.33	24	10.39	38	16.45	52	22.52	66	28.58
11	4.76	25	10.82	39	16.89	53	22.95	67	29.02
12	5.20	26	11.26	40	17.32	54	23.39	68	29.45
13	5.63	27	11.69	41	17.75	55	23.82	69	29.88
14	6.06	28	12.12	42	18.19	56	24.26	70	30.32

Pressures in Pounds per Square Inch in Pipes, Etc., under different Heads of Water—Continued

Feet Head	Pressure per Square Inch	Feet Head	Pressure per Square Inch	Feet Head	Pressure per Square Inch	Feet Head	Pressure per Square Inch	Feet Head	Pressure per Square Inch
71	30.75	121	52.41	171	74.07	221	95.73	271	117.39
72	31.18	122	52.84	172	74.50	222	96.16	272	117.82
73	31.62	123	53.28	173	74.94	223	96.60	273	118.26
74	32.05	124	53.71	174	75.37	224	97.03	274	118.69
75	32 48	125	54.15	175	75.80	225	97.46	275	119.12
76	32.92	126	54.58	176	76.23	226	97.90	276	119.56
77	33.35	127	55.01	177	76.67	227	98.33	277	119.99
78	33.78	128	55.44	178	77.10	228	98.76	278	120.42
79	34.21	129	55.88	179	77.53	229	99.20	279	120.85
80	34.65	130	56.31	180	77.97	230	99.63	280	121.29
81	35.08	131	56 74	181	78.40	231	100.06	281	121.72
82	35.52	132	57.18	182	78 84	232	100.49	282	122.15
83	35.95	133	57.61	183	79 27	233	100.93	283	122.59
84	36.39	134	58.04	184	79.70	234	101.36	284	123.02
85	36.82	135	58.48	185	80.14	235	101.79	285	123.45
86	37.25	136	58.91	186	80.57	236	102.23	286	123.89
87	37.68	137	59.34	187	81.00	237	102.66	287	124.32
88	38.12	138	59.77	188	81.43	238	103.09	288	124.75
89	38.55	139	60.21	189	81.87	239	103.53	289	125.18
90	38.98	140	60.64	190	82.30	240	103.96	290	125.62
91	39.42	141	61.07	191	82.73	241	104.39	291	126.05
92	39.85	142	61.51	192	83.17	242	104.83	292	126.48
93	40.28	143	61.94	193	83.60	243	105.26	293	126.92
94	40.72	144	62.37	194	84.03	244	105.69	294	127.35
95	41.15	145	62 81	195	84.47	245	106.13	295	127.78
96	41.58	146	63.24	196	84.90	246	106.56	296	128.22
97	42.01	147	63.67	197	85.33	247	106.99	297	128.65
98	42.45	148	64.10	198	85.76	248	107.43	298	129.08
99	42.88	149	64.54	199	86.20	249	107.86	299	129.51
100	43.31	150	64.97	200	86.63	250	108.29	300	129.95
101	43.75	151	65.40	201	87.07	251	108.73	310	134.28
102	44.18	152	65.84	202	87.50	252	109.16	320	138.62
103	44.61	153	66.27	203	87.93	253	109.59	330	142.95
104	45.05	154	66.70	204	88.36	254	110.03	340	147.28
105	45.48	155	67.14	205	88.80	255	110.46	350	151.61
106	45.91	156	67.57	206	89.23	256	110.89	360	155.94
107	46.34	157	68.00	207	89.66	257	111.32	370	160.27
108	46.78	158	68.43	208	90.10	258	111.76	380	164.61
109	47.21	159	68.87	209	90.53	259	112.19	390	168.94
110	47 64	160	69.31	210	90.96	260	112.62	400	173.27
111	48.08	161	69.74	211	91.39	261	113.06	500	216.58
112	48.51	162	70.17	212	91.83	262	113.49	600	259.90
113	48 94	163	70.61	213	92.26	263	113.92	700	303.22
114	49.38	164	71.04	214	92.69	264	114.36	800	346.54
115	49.81	165	71.47	215	93.13	265	114.79	900	389,86
116	50.24	166	71.91	216	93.56	266	115.22	1000	433.18
117	50.68	167	72.34	217	93.99	267	115.66	. .	. . .
118	51.11	168	72.77	218	94.43	268	116.09	. .	. . .
119	51.54	169	73.20	219	94.86	269	116.52	. .	. . .
120	51.98	170	73.64	220	95.30	270	116.96	. .	. . .

TABLE OF WATER ANALYSES

Grains per U. S. Gallon, 231 Cubic Inches

Where From	Lime and Magnesia Carbonates	Lime and Magnesia Sulphates	Sodium Chloride (Salt)	Iron Oxide, Carb. Sulph., etc.	Volatile and Organic Matter	Total Solids in Grains
Buffalo, N. Y., Lake Erie,	5.66	3.32	0.58	. . .	0.18	9.74
Pittsburgh, Allegheny River,	0.37	3.78	0.58	0.37	1.50	6.60
Pittsburgh, Monongahela River,	1.06	5.12	0.64	0.78	3.20	10.80
Milwaukee, Wisconsin River,	6.23	4.67	1.76	20.14	6.50	39.30
Galveston, Texas, 1,	13.68	13.52	326.64	Trace	Trace	353.84
Columbus, Ohio,	20.76	11.74	7.02	0.58	6.50	46.60
Washington, D. C., city supply,	2.87	3.27	Trace	0.36	2.10	8.60
Baltimore, Md., city supply,	2.77	0.65	Trace	0.10	3.80	7.30
Sioux City, Ia., city supply,	19.76	1.24	1.17	1.03	4.40	27.60
Los Angeles, Cal., 1,	10.12	5.84	3.51	2.63	4.10	26.20
Bay City, Michigan, Bay,	8.47	10.36	20.48	1.15	8.74	49.20
Bay City, Michigan, River,	4.84	33.66	126.78	3.00	10.92	179.20
Cincinnati, Ohio River,	3.88	0.78	1.79	. . .	Trace	6.73
Watertown, Conn.,	1.47	4.51	1.76	Trace	1.78	9.52
Ft. Wayne, Ind.,	8.78	6.22	3.51	1.59	10.98	31.08
Wilmington, Del.,	10.04	6.02	4.29	8.48	6.17	35.00
Galveston, Texas, 2,	21.79	29.149	398.99	. .	4.00	453.93
Wichita, Kansas,	14.14	25.91	24.34	. .	2.00	66.39
Los Angeles, Cal., 2,	3.72	12.59	. . .	0.76	6.00	23.07
St. Louis, Mo., well water,	27.04	23.73	15.57	3.49	0.46	70.29
Pittsburgh, Pa., artesian well,	23.45	5.71	18.41	1.04	0.82	49.43
Springfield, Ill., 1,	12.99	7.40	1.97	2.19	8.62	33.17
Springfield, Ill., 2,	5.47	4.31	1.56	4.28	5.83	21.45
Hillsboro, Ill.,	14.56	2.97	2.39	1.63	Trace	21.55
Pueblo, Colo.,	4.32	16.15	1.20	1.97	5.12	28.76
Long Island City, L. I.,	4.0	28.0	16.0	. . .	1.0	39.0
Mississippi River, above Missouri River,	8.24	1.02	0.50	. . .	5.25	15.01
Mississippi River, below mouth of Missouri River,	10.64	7.41	1.36	1.22	15.86	36.49
Mississippi River at St. Louis W. W.,	9.64	6.94	1.54	1.57	9.85	29.54
Missouri River, above mouth,	10.07	8.92	1.87	3.26	11.37	35.49

STEAM

Steam is an elastic fluid resulting from the combination of heat with water, and when the steam is not in contact with the water from which it is formed, it follows the same general law as all other gases. This law is as follows: All gases expand by heat $\frac{1}{491}$ part of their volume for every degree Fahr., while their elastic pressure remains unaltered; and so long as the temperature of a gas remains unaltered, its elastic pressure will vary inversely to the volume. Steam is of several kinds. *Superheated steam* is steam removed from contact with water and heated to a temperature higher than is due to its pressure; called also *surcharged steam*. *Saturated steam* is steam which, in contact with the fluid from which it is formed, has brought with it a proportion of moisture. *Supersaturated steam* is steam in which there is more water mingled in the form of minute spray than is generally contained in saturated steam, which is called the water of supersaturation.

The temperature of the steam is always equal to that of water from which it is formed, and the elastic force of steam formed is equal to the pressure under which it is formed. The elastic force of steam, barometer at 30°, at 212° Fahr., is one atmosphere, or 14.7 lbs. per square inch; while at 250° Fahr. its elastic force is two atmospheres, or 29.4 lbs. per square inch. This includes the pressure of the atmosphere.

FLOW OF STEAM THROUGH PIPES

The approximate weight of any fluid which will flow in one minute through any given pipe with a given head or pressure may be found by the following formula:

$$W = 87 \sqrt{\frac{D\,(p_1 - p_2)\,d^5}{L\left(1 + \frac{3.6}{d}\right)}}$$

in which W = weight in pounds avoirdupois, d = diameter in inches, D = density or weight per cubic foot; p_1 the initial pressure, p_2 pressure at end of pipe, and L = the length in feet.

The table on page 131 gives, approximately, the weight of steam per minute which will flow from various initial pressures, with one pound loss of pressure through straight, smooth pipes, each having a length of 240 times its own diameter.

For sizes of pipe below 6-inch, the flow is calculated from the *actual* areas of "standard" pipe of such nominal diameters.

For horse power, multiply the figures in the table by 2. For any other loss of pressure, multiply by the square root of the given loss. For any other length of pipe, *divide 240 by the given length expressed in diameters, and multiply the figures in the table by the square root of this quotient*, which will give the flow for 1 pound loss of pressure. Conversely, dividing the given length by 240 will give the loss of pressure for the flow given in the table.

The loss of head due to getting up the velocity, to the friction of the steam entering the pipe, and passing elbows and valves, will reduce the flow given in the tables. The resistance at the opening, and that at a globe valve, are each about the same as that for a length of pipe equal to 114 diameters divided by a number represented by $1 + (3.6 \div \text{diameter})$. For the sizes of pipes given in the table, these corresponding lengths are:

¾	1	1½	2	2½	3	4	5	6	8	10	12	15	18
20	25	34	41	47	52	60	66	71	79	84	88	92	95

The resistance at an elbow is equal to two-thirds that of a globe valve. These equivalents,—for opening, for

elbows, and for valves,—must be added in each instance to the actual length of pipe. Thus a 4-inch pipe, 120 diameters (40 feet) long, with a globe valve and three elbows, would be equivalent to $120 + 60 + 60 + (3 \times 40) = 360$ diameters long; and $360 \div 240 = 1\frac{1}{2}$. It would therefore have $1\frac{1}{2}$ pounds loss of pressure at the flow given in the table, or deliver $(1 \div \sqrt{1\frac{1}{2}} = .816)$, 81.6 per cent. of the steam with the same (1 pound) loss of pressure.

COVERING FOR BOILERS, STEAM PIPES, ETC.

The loss by radiation from unclothed pipes and vessels containing steam is considerable, and in the case of pipes leading to steam engines, is magnified by the action of the condensed water in the cylinder. It therefore is important that such pipes should be well protected.

There is a wide difference in the value of different substances for protection from radiation, their value varying nearly in the inverse ratio of their conducting power for heat, up to their ability to transmit as much heat as the surface of the pipe will radiate, after which they become detrimental, rather than useful, as covering. This point is reached nearly at baked clay or brick.

The table on page 132, giving the relative value of various substances for protection against radiation, has been compiled from a variety of sources, mainly the experiments of the Massachusetts Institute of Technology, and of C. E. Emery, M.E., LL.D.

Where two values are given in the table for the same substance, the lower one is for the denser condition.

A smooth or polished surface is of itself a good protection, polished tin or Russia iron having a ratio, for radiation, of 53 to 100 for cast iron. Mere color makes but little difference.

Hair or wool felt, and most of the better non-conductors, have the disadvantage of becoming soon charred from the heat of steam at high pressure, and sometimes of taking fire therefrom.

"Mineral wool," a fibrous material made from blast furnace slag, is the best non-combustible covering, but is quite brittle, and liable to fall to powder where much jarring exists.

Air space alone is one of the poorest of non-conductors, though the best owe their efficiency to the numerous minute air-cells in their structure. This is best seen in the value of different forms of carbon, from cork charcoal to anthracite dust, the former being three times as valuable for this purpose, though in chemical constitution they are practically identical.

Any suitable substance used to prevent the escape of steam heat should not be less than one inch thick.

The table on page 133 gives the loss of heat from steam pipes, naked and clothed with wool or hair felt of different thicknesses, the steam pressure being assumed at 75 lbs. and the external air at 60°.

TABLE OF FLOW OF STEAM THROUGH PIPES

Initial Pressure by Gauge Lbs. per Sq. Inch	Diameter of Pipe in Inches. Length of Each = 240 Diameters													
	¾	1	1½	2	2½	3	4	5	6	8	10	12	15	18
	Weight of Steam per Minute in Pounds, with One Pound Loss of Pressure													
1	1.16	2.07	5.7	10.27	15.45	25.38	46.85	77.3	115.9	211.4	341.1	502.4	804	1177
10	1.44	2.57	7.1	12.72	19.15	31.45	58.05	95.8	143.6	262.0	422.7	622 5	996	1458
20	1.70	3.02	8.3	14.94	22.49	36.94	68.20	112.6	168.7	307.8	496.5	731.3	1170	1713
30	1.91	3.40	9.4	16 84	25.35	41.63	76.84	126.9	190.1	346.8	559.5	824.1	1318	1930
40	2.10	3.74	10.3	18.51	27.87	45.77	84.49	139.5	209.0	381.3	615.3	906.0	1450	2122
50	2.27	4.04	11.2	20.01	30.13	49.48	91.34	150.8	226.0	412.2	665.0	979.5	1567	2294
60	2.43	4.32	11.9	21.38	32.19	52.87	97.60	161.1	241.5	440.5	710.6	1046.7	1675	2451
70	2.57	4.58	12.6	22.65	34.10	56.00	103.37	170.7	255.8	466.5	752.7	1108.5	1774	2596
80	2.71	4.82	13.3	23.82	35.87	58.91	108.74	179.5	269.0	490.7	791.7	1166.1	1866	2731
90	2.83	5.04	13.9	24.92	37.52	61.62	113.74	187.8	281.4	513.3	828.1	1219 8	1951	2856
100	2.95	5.25	14.5	25.96	39.07	64.18	118.47	195.6	293.1	534.6	862.6	1270.1	2032	2975
120	3.16	5.63	15.5	27.85	41.93	68.87	127.12	209.9	314.5	573.7	925.6	1363.3	2181	3193
150	3.45	6.14	17.0	30.37	45.72	75.09	138.61	228.8	343.0	625.5	1009.2	1486.5	2378	3481

TABLE OF RELATIVE VALUE OF NON-CONDUCTING MATERIALS

Substance	Value	Substance	Value
* Loose Wool,	3.35	* Wood, across grain,	.40 to .55
* Loose Lampblack,	1.12	Loam, dry and open,	.55
* Geese Feathers,	1.08	Chalk, ground, Spanish white,	.51
* Felt, Hair or Wool,	1.	Coal Ashes,	.35 to .49
* Carded Cotton,	1.	Gas-house Carbon,	.47
* Charcoal from Cork,	.87	Asbestos Paper,	.47
Mineral Wool,	.68 to .83	Paste of Fossil Meal and Asbestos,	.47
Fossil Meal,	.66 to .79	Asbestos, fibrous,	.36
* Straw Rope, wound spirally,	.77	Plaster of Paris, dry,	.34
* Rice Chaff, loose,	.76	Clay, with vegetable fibre,	.34
Carbonate Magnesia,	.67 to .76	Anthracite Coal, powdered,	.29
* Charcoal from Wood,	.63 to .75	Coke, in lumps,	.27
* Paper,	.50 to .74	Air Space, undivided,	.14 to .22
* Cork,	.71	Sand,	.17
* Sawdust,	.61 to .68	Baked Clay, Brick,	.07
Paste of Fossil Meal and Hair,	.63	Glass,	.05
Wood Ashes,	.61	Stone,	.02

* Combustible and sometimes dangerous.

TABLE OF LOSS OF HEAT FROM STEAM PIPES

Thickness of Covering in Inches	Outside Diameter of Pipe, without Felt														
	2 In. Diameter			4 In. Diameter			6 In. Diameter			8 In. Diameter			12 In. Diameter		
	Loss in Units per Foot Run per Hour	Ratio of Loss	Feet in Length per H. P. Lost	Loss in Units per Foot Run per Hour	Ratio of Loss	Feet in Length per H. P. Lost	Loss in Units per Foot Run per Hour	Ratio of Loss	Feet in Length per H. P. Lost	Loss in Units per Foot Run per Hour	Ratio of Loss	Feet in Length per H. P. Lost	Loss in Units per Foot Run per Hour	Ratio of Loss	Feet in Length per H. P. Lost
0	219.0	1.00	152	390.8	1.00	86	624.1	1.000	53	729.8	.000	46	1077.4	1.000	81
¼	100.7	.46	331	180.9	.46	182	. .	. .	. .	. .	. .	. .	. .	. .	. .
½	65.7	.30	507	117.2	.30	284	187.2	.300	177	219.6	.301	151	301.7	.280	114
1	43.8	.20	761	73.9	.18	451	111.0	.178	300	128.3	.176	259	185.3	.172	179
2	28.4	.13	1173	44.7	.11	745	66.2	.106	504	75.2	.103	443	98.0	.091	340
4	19.8	.09	1683	28.1	.07	1186	41.2	.066	898	46.0	.063	724	60.3	.056	553
6	. .	. .	. .	23.4	.06	1424	33.7	.054	989	34.3	.047	972	45.2	.042	735

TABLE OF PROPERTIES OF SATURATED STEAM

(PARTLY FROM C. H. PEABODY'S TABLES)

Pressure in Pounds per Square Inch above Vacuum	Temperature in Degrees Fahrenheit	Total Heat in Heat Units from Water at 32°	Heat in Liquid from 32° in Units	Heat of Vaporization, or Latent Heat in Heat Units	Density or Weight per Cubic Foot in Pounds	Volume of One Pound in Cubic Feet	Factor of Equivalent Evaporation at 212°	Total Pressure above Vacuum
1	101.99	1113.1	70.0	1043.0	0.00299	334.5	.9661	1
2	126.27	1120.5	94.4	1026.1	0.00576	173.6	.9738	2
3	141.62	1125.1	109.8	1015.3	0.00844	118.5	.9786	3
4	153.09	1128.6	121.4	1007.2	0.01107	90.33	.9822	4
5	162.34	1131.5	130.7	1000.8	0.01366	73.21	.9852	5
6	170.14	1133.8	138.6	995.2	0.01622	61.65	.9876	6
7	176.90	1135.9	145.4	990.5	0.01874	53.39	.9897	7
8	182.92	1137.7	151.5	986.2	0.02125	47.06	.9916	8
9	188.33	1139.4	156.9	982.5	0.02374	42.12	.9934	9
10	193.25	1140.9	161.9	979.0	0.02621	38.15	.9949	10
15	213.03	1146.9	181.8	965.1	0.03826	26.14	1.0003	15
20	227.95	1151.5	196.9	954.6	0.05023	19.91	1.0051	20
25	240.04	1155.1	209.1	946.0	0.06199	16.13	1.0099	25
30	250.27	1158.3	219.4	938.9	0.07360	13.59	1.0129	30
35	259.19	1161.0	228.4	932.6	0.08508	11.75	1.0157	35
40	267.13	1163.4	236.4	927.0	0.09644	10.37	1.0182	40
45	274.29	1165.6	243.6	922.0	0.1077	9.285	1.0205	45
50	280.85	1167.6	250.2	917.4	0.1188	8.418	1.0225	50
55	286.89	1169.4	256.3	913.1	0.1299	7.698	1.0245	55
60	292.51	1171.2	261.9	909.3	0.1409	7.097	1.0263	60
65	297.77	1172.7	267.2	905.5	0.1519	6.583	1.0280	65
70	302.71	1174.3	272.2	902.1	0.1628	6.143	1.0295	70
75	307.38	1175.7	276.9	898.8	0.1736	5.760	1.0309	75
80	311.80	1177.0	281.4	895.6	0.1843	5.426	1.0323	80
85	316.02	1178.3	285.8	892.5	0.1951	5.126	1.0337	85
90	320.04	1179.6	290.0	889.6	0.2058	4.859	1.0350	90
95	323.89	1180.7	294.0	886.7	0.2165	4.619	1.0362	95
100	327.58	1181.9	297.9	884.0	0.2271	4.403	1.0374	100
105	331.13	1182.9	301.6	881.3	0.2378	4.205	1.0385	105
110	334.56	1184.0	305.2	878.8	0.2484	4.026	1.0396	110
115	337.86	1185.0	308.7	876.3	0.2589	3.862	1.0406	115
120	341.05	1186.9	312.0	874.0	0.2695	3.711	1.0416	120
125	344.13	1186.0	315.2	871.7	0.2800	3.571	1.0426	125
130	347.12	1187.8	318.4	869.4	0.2904	3.444	1.0435	130
140	352.85	1189.5	324.4	865.1	0.3113	3.212	1.0453	140
150	358.26	1191.2	330.0	861.2	0.3321	3.011	1.0470	150
160	363.40	1192.8	335.4	857.4	0.3530	2.833	1.0486	160
170	368.29	1194.3	340.5	853.8	0.3737	2.676	1.0502	170
180	372.97	1195.7	345.4	850.3	0.3945	2.535	1.0517	180
190	377.44	1197.1	350.1	847.0	0.4153	2.408	1.0531	190
200	381.73	1198.4	354.6	843.8	0.4359	2.294	1.0545	200
225	391.79	1201.4	365.1	836.3	0.4876	2.051	1.0576	225
250	400.99	1204.2	374.7	829.5	0.5393	1.854	1.0605	250
275	409.50	1206.8	383.6	823.2	0.5913	1.691	1.0632	275
300	417.42	1209.3	391.9	817.4	0.644	1.553	1.0657	300
325	424.82	1211.5	399.6	811.9	0.696	1.437	1.0680	325
350	431.90	1213.7	406.9	806.8	0.748	1.337	1.0703	350
375	438.40	1215.7	414.2	801.5	0.800	1.250	1.0724	375
400	445.15	1217.7	421.4	796.3	0.853	1.172	1.0745	400
500	466.57	1224.2	444.3	779.9	1.065	.939	1.0812	500

The gauge pressure is about 15 pounds (14.7) less than the total pressure, so that in using the table on preceding page, 15 must be added to the pressure as given by the steam gauge. The column of Temperatures gives the thermometric temperature of steam and the boiling point at each pressure. The "factor of equivalent evaporation" shows the proportionate cost in heat or fuel of producing steam at the given pressure as compared with atmospheric pressure.

To ascertain the equivalent evaporation at any pressure, multiply the given evaporation by the factor of its pressure, and divide the product by the factor of the desired pressure.

Each degree of difference in temperature of feed-water makes a difference of .00104 in the amount of evaporation. Hence, to ascertain the equivalent evaporation from any other temperature of feed than 212°, add to the factor given as many times .00104 as the temperature of feed-water is degrees below 212°. For other pressures than those given in the table, it will be practically correct to take the proportion of the difference between the nearest pressures given in the table.

DIMENSIONS AND AREAS OF STEAM, GAS, AND WATER PIPE

Diameter			Thickness	Circumference		Transverse Areas			Length of Pipe per Sq. Foot of		Length of Pipe contain'g One Cubic Foot	Nominal Weight per Foot	Number of Threads per Inch of Screw
Nominal Int'l	Actual Ext'l	Actual Int'l		Ext'l	Int'l	Ext'l	Int'l	Metal	Ext'l Surface	Int'l Surface			
Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Sq. Ins.	Sq. Ins.	Sq. Ins.	Feet	Feet	Feet	Lbs.	. . .
1/8	.405	.27	.068	1.272	.848	.129	.0573	.0717	9.44	14.15	2513.	.241	27
1/4	.54	.364	.088	1.696	1.144	.229	.1041	.1249	7.075	10.49	1383.3	.42	18
3/8	.675	.494	.091	2.121	1.552	.358	.1917	.1663	5.657	7.73	751.2	.559	18
1/2	.84	.623	.109	2.639	1.957	.554	.3048	.2492	4.547	6.13	472.4	.837	14
3/4	1.05	.824	.113	3.299	2.589	.866	.5333	.3327	3.637	4.635	270.	1.115	14
1	1.315	1.048	.134	4.131	3.292	1.358	.8626	.4954	2.904	3.645	166.9	1.668	11½
1¼	1.66	1.38	.14	5.215	4.335	2.164	1.496	.668	2.301	2.768	96.25	2.244	11½
1½	1.9	1.611	.145	5.969	5.061	2.835	2.038	.797	2.01	2.371	70.66	2.678	11½
2	2.375	2.067	.154	7.461	6.494	4.43	3.356	1.074	1.608	1.848	42.91	3.609	11½
2½	2.875	2.468	.204	9.032	7.753	6.492	4.784	1.708	1.328	1.547	30.1	5.739	8
3	3.5	3.067	.217	10.996	9.636	9.621	7.388	2.243	1.091	1.245	19.5	7.536	8
3½	4.	3.548	.226	12.566	11.146	12.566	9.887	2.679	.955	1.077	14.57	9.001	8
4	4.5	4.026	.237	14.137	12.648	15.904	12.73	3.174	.849	.949	11.31	10.665	8
4½	5.	4.508	.246	15.708	14.162	19.635	15.961	3.674	.764	.848	9.02	12.34	8
5	5.563	5.045	.259	17.477	15.819	24.306	19.99	4.316	.687	.757	7.2	14.502	8
6	6.625	6.065	.28	20.813	19.054	34.472	28.888	5.584	.577	.63	4.98	18.762	8

DIMENSIONS AND AREAS OF STEAM, GAS, AND WATER PIPE—Continued

Diameter			Thickness	Circumference		Transverse Areas			Length of Pipe per Sq. Foot of		Length of Pipe contain'g One Cubic Foot	Nominal Weight per Foot	Number of Threads per Inch of Screw
Nominal Int'l	Actual Ext'l	Actual Int'l		Ext'l	Int'l	Ext'l	Int'l	Metal	Ext'l Surface	Int'l Surface			
Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Sq. Ins.	Sq. Ins.	Sq. Ins.	Feet	Feet	Feet	Lbs.	. .
7	7.625	7.023	.301	23.955	22.063	45.664	38.738	6.926	.501	.544	3.72	23.271	8
8	8.625	7.982	.322	27.096	25.076	58.426	50.04	8.386	.443	.478	2.88	28.177	8
9	9.625	8.937	.344	30.238	28.076	72.76	62.73	10.03	.397	.427	2.29	33.701	8
10	10.75	10.019	.366	33.772	31.477	90.763	78.839	11.924	.355	.382	1.82	40.065	8
11	12.	11.25	.375	37.699	35.343	113.098	99.402	13.696	.318	.339	1.456	45.95	8
12	12.75	12.	.375	40.055	37.7	127.677	113.098	14.579	.299	.319	1.27	48.985	8
13	14.	13.25	.375	43.982	41.626	153.938	137.887	16.051	.273	.288	1.04	53.921	8
14	15.	14.25	.375	47.124	44.768	176.715	159.485	17.23	.255	.268	.903	57.893	8
15	16.	15.25	.375	50.265	47.909	201.062	182.655	18.407	.239	.250	.788	61.77	8
. .	18.	17.25	.375	56.549	54.192	254.47	233.706	20.764	.212	.221	.616	69.66	. .
. .	20.	19.25	.375	62.832	60.476	314.16	291.04	23.12	.191	.198	.495	77.57	. .
. .	22.	21.25	.375	69.115	66.759	380.134	354.657	25.477	.174	.179	.406	85.47	. .
. .	24.	23.25	.375	75.398	73.042	452.39	424.558	27.832	.159	.164	.339	93.37	. .

DIMENSIONS AND AREAS OF STANDARD EXTRA STRONG PIPE

Diameter			Thickness	Circumference		Transverse Areas			Length of Pipe in Ft. per Sq. Ft. of		Nom. Weight per Ft. Pounds	Threads per In.
Nom.	External	Internal		External	Internal	External	Internal	Metal	Ext'l Surface	Int'l Surface		
1/8	.405	.205	.100	1.272	.644	.129	.033	.096	9.44	18.63	.29	27
1/4	.540	.294	.123	1.696	.924	.229	.068	.161	7.07	12.99	.54	18
3/8	.675	.421	.127	2.121	1.323	.358	.139	.219	5.66	9.07	.74	18
1/2	.840	.542	.149	2.639	1.703	.554	.231	.323	4.55	7.05	1.09	14
3/4	1.050	.736	.157	3.299	2.312	.866	.425	.441	3.64	5.11	1.39	14
1	1.315	.951	.182	4.131	2.988	1.358	.710	.648	2.90	4.02	2.17	11½
1¼	1.660	1.272	.194	5.215	3.996	2.164	1.271	.893	2.30	3.00	3.00	11½
1½	1.900	1.494	.203	5.969	4.694	2.835	1.753	1.082	2.01	2.56	3.63	11½
2	2.375	1.933	.221	7.461	6.073	4.430	2.935	1.495	1.61	1.97	5.02	11½
2½	2.875	2.315	.280	9.032	7.273	6.492	4.209	2.283	1.33	1.65	7.67	8
3	3.500	2.892	.304	10.996	9.086	9.621	6.569	3.052	1.09	1.33	10.25	"
3½	4.000	3.358	.321	12.566	10.549	12.566	8.856	3.710	.955	1.14	12.47	"
4	4.500	3.818	.341	14.137	11.995	15.904	11.449	4.455	.849	1.00	14.97	"
4½	5.000	4.280	.360	15.708	13.446	19.635	14.387	5.248	.764	.893	18.22	"
5	5.563	4.813	.375	17.477	15.120	24.306	18.193	6.113	.687	.793	20.54	"
6	6.625	5.751	.437	20.813	18.067	34.472	25.976	8.496	.577	.664	28.58	"
7	7.625	6.625	.500	23.955	20.813	45.664	34.472	11.192	.501	.598	37.67	"
8	8.625	7.625	.500	27.096	23.955	58.426	45.664	12.762	.443	.502	43.00	"
9	9.625	8.625	.500	30.238	27.096	72.760	58.426	14.334	.397	.443	48.25	"
10	10.750	9.750	.500	33.772	30.631	90.763	74.662	16.101	.355	.399	54.25	"
12	12.750	11.750	.500	40.055	36.914	127.68	108.43	19.25	.299	.325	65.00	"

DIMENSIONS AND AREAS OF STANDARD DOUBLE EXTRA STRONG PIPE

Diameter			Thick-ness	Circumference		Transverse Areas			Length of Pipe in Ft. per Sq. Ft. of		Nom. Weight per Ft. Pounds	Threads per In.
Nom.	External	Internal		External	Internal	External	Internal	Metal Area	Ext'l Surface	Int'l Surface		
½	.840	.244	.298	2.639	.767	.554	.047	.507	4.55	15.67	1.7	14
¾	1.050	.422	.314	3.299	1.326	.866	.140	.726	3.64	9.05	2.44	14
1	1.315	.587	.364	4.131	1.844	1.358	.271	1.087	2.90	6.51	3.65	11½
1¼	1.660	.885	.388	5.215	2.780	2.164	.615	1.549	2.30	4.32	5.2	11½
1½	1.900	1.088	.406	5.969	3.418	2.835	.930	1.905	2.01	3.51	6.4	11½
2	2.375	1.491	.442	7.461	4.684	4.430	1.744	2.686	1.61	2.56	9.02	11½
2½	2.875	1.755	.560	9.032	5.514	6.492	2.419	4.073	1.33	2.18	13.68	8
3	3.500	2.284	.608	10.996	7.176	9.621	4.097	5.524	1.09	1.67	18.56	"
3½	4.000	2.716	.642	12.566	8.533	12.566	5.794	6.772	.955	1.41	22.75	"
4	4.500	3.136	.682	14.137	9.852	15.904	7.724	8.180	.849	1.22	27.48	"
4½	5.000	3.564	.718	15.708	11.197	19.635	9.976	9.659	.764	1.07	32.53	"
5	5.563	4.063	.750	17.477	12.764	24.306	12.965	11.341	.687	.94	38.12	"
6	6.625	4.875	.875	20.813	15.315	34.472	18.665	15.807	.577	.78	53.11	"
7	7.625	5.875	.875	23.955	18.457	45.664	27.109	18.555	.501	.65	62.38	"
8	8.625	6.875	.875	27.096	21.598	58.426	37.122	21.304	.443	.55	71.62	"

TABLE OF EQUATION OF PIPES

The table below gives the number of pipes of one size required to equal in delivery other larger pipes of same length and under same conditions. The upper portion above the diagonal line of blanks pertains to "standard" steam and gas pipes, while the lower portion is for pipes of the ACTUAL internal diameters given. The figures given in the table opposite the intersection of any two sizes is the number of the smaller-sized pipes required to equal one of the larger. Thus, it requires 29 standard 2-inch pipes to equal one standard 7-inch pipe.

STANDARD STEAM AND GAS PIPES

Dia.	½	¾	1	1½	2	2½	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Dia.
½		2.27	4.88	15.8	31.7	52.9	96.9	205	377	620	918	1292	1767	2488	3014	3786	4904	5927	7321	8535	9717	½
¾	2.60		2.05	6.97	14.0	23.3	42.5	90.4	166	273	405	569	779	1096	1328	1668	2161	2615	3226	3761	4282	¾
1	7.55	2.90		3.45	6.82	11.4	20.9	44.1	81.1	133	198	278	380	536	649	815	1070	1263	1576	1837	2092	1
1½	24.2	9.30	3.20		1.26	3.34	6.13	13.0	23.8	39.2	58.1	81.7	112	157	190	239	310	375	463	539	614	1½
2	54.8	21.0	7.25	2.26		1.67	3.06	6.47	11.9	19.6	29.0	40.8	55.8	78.5	95.1	119	155	187	231	269	307	2
2½	102	39.4	13.6	4.23	1.87		1.83	3.87	7.12	11.7	17.4	24.4	33.4	47.0	56.9	71.5	92.6	112	138	161	184	2½
3	170	65.4	22.6	7.03	3.11	1.66		2.12	3.89	6.39	9.48	13.3	20.9	23.7	31.2	39.1	50.6	61.1	75.5	88.0	100	3
4	376	144	49.8	15.5	6.87	3.67	2.21		1.84	3.02	4.48	6.30	8.61	12.1	14.7	18.5	23.9	28.9	35.7	41.6	47.4	4
5	686	263	90.9	28.3	12.5	6.70	4.63	1.83		1.65	2.44	3.43	4.69	6.60	8.00	10.0	13.0	15.7	19.4	22.6	25.8	5
6	1116	429	148	46.0	20.4	10.9	6.56	2.97	1.63		1.48	2.09	2.85	4.02	4.86	6.11	7.91	9.56	11.8	13.8	15.6	6
7	1707	656	226	70.5	31.2	16.6	10.0	4.54	2.49	1.51		1.41	1.93	2.71	3.28	4.12	5.34	6.45	7.97	9.31	10.6	7
8	2435	936	322	101	44.5	23.8	14.3	6.48	3.54	2.18	1.43		1.35	1.93	2.33	2.92	3.79	4.57	5.67	6.60	7.52	8
9	3335	1281	440	137	60.8	32.5	19.5	8.85	4.85	2.98	1.95	1.37		1.41	1.71	2.14	2.77	3.35	4.14	4.83	5.50	9
10	4393	1688	582	181	80.4	42.9	25.8	11.7	6.40	3.93	2.57	1.80	1.32		1.21	1.52	1.97	2.38	2.94	3.43	3.91	10
11	5642	2168	747	233	103	55.1	33.1	15.0	8.22	5.05	3.31	2.32	1.70	1.28		1.26	1.63	1.88	2.43	2.83	3.22	11
12	7087	2723	938	293	129	69.2	41.6	18.8	10.3	6.34	4.15	2.91	2.13	1.61	1.26		1.30	1.57	1.93	2.26	2.58	12
13	8657	3326	1146	358	158	84.5	50.7	23.0	12.6	7.75	5.07	3.56	2.60	1.98	1.53	1.22		1.21	1.49	1.74	1.98	13
14	10600	4070	1403	438	193	103	62.2	28.2	15.4	9.48	6.21	4.35	3.18	2.41	1.88	1.50	1.22		1.24	1.44	1.64	14
15	12824	4927	1698	530	234	125	75.3	34.1	18.7	11.5	7.52	5.27	3.85	2.92	2.27	1.81	1.48	1.21		1.17	1.35	15
16	14978	5758	1984	619	274	146	88.0	39.9	21.8	13.4	8.78	6.15	4.51	3.41	2.66	2.12	1.73	1.42	1.18		1.14	16
17	17537	6738	2322	724	320	171	103	46.6	25.6	15.7	10.3	7.20	5.27	3.99	3.11	2.47	2.03	1.66	1.37	1.17		
18	20327	7810	2691	840	371	198	119	54.1	29.6	18.2	11.9	8.35	6.11	4.63	3.60	2.87	2.35	1.92	1.59	1.36	1.16	
20	26676	10249	3532	1102	487	260	157	70.9	38.9	23.9	15.6	10.9	8.02	6.07	4.73	3.76	3.08	2.52	2.08	1.78	1.52	
24	42624	16376	5644	1761	778	416	250	113	62.1	38.2	25.0	17.5	12.8	9.70	7.55	6.01	4.92	4.02	3.32	2.84	2.43	
30	75453	28990	9990	3117	1378	736	443	201	110	67.6	44.2	31.0	22.7	17.2	13.4	10.7	8.72	7.14	5.88	5.03	4.80	
36	120100	46143	15902	4961	2193	1172	705	319	175	108	70.4	49.3	36.1	27.3	21.3	16.9	13.9	11.3	9.37	8.01	6.85	
42	177724	68282	23531	7341	3245	1734	1044	473	259	159	104	73.0	53.4	40.5	31.5	25.1	20.5	16.8	13.9	11.9	10.1	
48	249351	95818	33020	10301	4554	2434	1465	663	363	223	146	102	75.0	56.8	44.2	35.2	28.8	23.5	19.4	16.6	14.2	
Dia.	½	¾	1	1½	2	2½	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	

ACTUAL INTERNAL DIAMETERS

VENTILATION; STEAM AND HOT WATER HEATING

In ventilating apartments, from 3.5 to 5 cubic feet of air is required per minute in winter, and 5 to 10 feet in summer, for each occupant. In hospitals, this rate must be materially increased.

In heating buildings by steam, the amount of boiler and heating pipe depends largely on the kind of building, its location, and the following conditions: Whether building is protected or isolated; whether stone or wood; amount of glass and outside wall surface to space to be heated, and also largely upon the exposure of rooms. Without this information it is impossible to correctly estimate the amount of radiator surface. We give below results obtained by averaging the different existing conditions.

	One Sq. Ft. of Radiating Surface Heats	
	Low Pressure Steam	Hot Water
	Cubic Feet	Cubic Feet
Living rooms with three exposures and large amount of glass, . .	40	20 to 25
Living rooms with two exposures and ordinary amount of glass, .	50	25 to 30
Living rooms with one exposure and ordinary windows, ...	60	30 to 35
Halls located on corner, ...	55	30 to 33
Halls located in centre of house, .	70	35 to 40
Bath and small exposed rooms, . .	40	20 to 25
Sleeping-rooms, ...	60 to 70	25 to 35
School rooms, ...	60 to 80	30 to 50
Churches and auditoriums, ...	75 to 125	80 to 100
Offices, ...	60 to 80	30 to 50
Stores, ...	70 to 100	40 to 70
Theatres, ...	200 to 300	

The foregoing figures are based on zero weather. If extreme is above zero, less can be used, and if below, the radiators should be increased.

For *indirect* radiators add at least 50 per cent. to the above ratings; for *direct-indirect*, add 25 per cent.

The best results are attained by using indirect radiation to supply the necessary ventilation, and direct radiation for the balance of the heat. The best place for a radiator in a room is beneath a window. Heated air cannot be made to enter a room unless means are provided for permitting an equal amount to escape. The best place for such exit openings is near the floor.

Small pipes are more effective than large. When the diameter is doubled, 20 per cent. additional surface should be allowed, and for three times the diameter, 30 per cent. additional is required. For indirect radiation that surface is most efficient which secures the most intimate contact of the current of air with the heated surface. Rooms on windward side of house require more radiating surface than those on sheltered side.

Where the condensed water is returned to the boiler, or where low pressure of steam is used, the diameter of mains leading from the boiler to the radiating surface should be equal, in inches, to *one-tenth the square root of the radiating surface,—mains included*, in square feet. Thus, a 1-inch pipe will supply 100 square feet of surface, itself included. Return pipes should be at least ¾ of an inch in diameter, and never less than *one-half* the diameter of the main—longer returns requiring larger

pipe. A thorough drainage of steam pipes will effectually prevent all cracking and pounding noises therein.

One square foot of boiler surface will supply from 7 to 10 square feet of radiating surface, depending upon the size of boiler and the efficiency of its surface, as well as that of the radiating surface. Small boilers for house use should be much larger proportionately than large plants. Each horse power of boiler will supply from 240 to 360 feet of 1-inch steam pipe, or 80 to 120 square feet of radiating surface.

Cubic feet of space has little to do with amount of steam or surface required, but is a convenient factor for rough calculations. Under ordinary conditions 1 horse power will heat, approximately, in—

	Cubic feet.
Brick dwellings, in blocks, as in cities, . .	15000 to 20000
" stores, in blocks, ...	10000 to 15000
" dwellings, exposed all round, . . .	10000 to 15000
" mills, shops, factories, etc., ...	7000 to 10000
Wooden dwellings, exposed, ...	7000 to 10000
Foundries and wooden shops, ...	6000 to 10000
Exhibition buildings, largely glass, etc., .	4000 to 15000

The system of heating mills and manufactories by means of pipes placed overhead is being largely adopted in preference to radiators near the floor, particularly for rooms in which there are shafting and belting to circulate the air.

In heating buildings, care should be taken to supply the necessary moisture to keep the air from being "dry" and uncomfortable. The capacity of air for moisture rises rapidly as it is heated, it being four times as great

at 72° as at 32°. For comfort, air should be kept at about "50 per cent. saturated." This would require one pound of vapor to be added to each 2500 cubic feet heated from 32° to 70°.

A much-needed attachment has recently been introduced, which acts automatically upon the steam valves of the radiators, or upon the hot-air registers and ventilators, and maintains the temperature in a room to within ½ a degree of any standard desired.

A "separator" acting by centrifugal force has been recently tested, and is very efficient in trapping out all the water entrained in steam. It will be found valuable, particularly where the steam has to be carried a long distance from the boiler, and for the purpose of preventing "hammering" of water in the pipes.

SIZES OF EXPANSION TANKS

Square Feet Radiation	Size Tanks	Capacity Gallons
150 to 300	12 x 20	10
325 to 500	12 x 30	15
525 to 700	14 x 30	20
725 to 900	16 x 30	26
925 to 1300	16 x 36	32
1325 to 2200	16 x 48	42
2225 to 3800	18 x 60	66
3900 to 5100	20 x 60	82

SHAFTING

POWER OF SHAFTS

The strength of a cylindrical shaft to resist torsion varies as d^3 (d = diameter) and is independent of the length, but torsional stiffness varies as $\frac{d^4}{L}$ (L = length) and it is necessary to consider both the strength and the stiffness in fixing the proper size for a shaft.

It is necessary to make a distinction between engine crank shafts and ordinary ones, and in that case the following formula may be used:

$P = \frac{d^3 \times R}{M}$ and $\frac{M \times P}{R} = d^3$, in which P = nominal horse power, R = number of revolutions, M = constant. The value of M for cast iron crank shafts for large engines, say 30 horse power, is 400, and for wrought iron 260. For ordinary shafts the value of M is 254 for cast iron, and 160 for wrought iron. Where there is a liability to sudden strain, extra strong shafting should be used. For shafts, say 4½ inches diameter and under, owing to their greater elasticity, a different rule from the above becomes necessary, and we have for ordinary wrought iron shafts the rules:

$$P = d^4 \times R \times .00135 \text{ and } \frac{P}{R \times .00135} = d^4.$$

PRESSURE PER SQUARE INCH ON BEARINGS

Bearings should be proportioned according to the pressure; otherwise the lubricant is squeezed out. This pressure may be as high as 700 lbs. to the square inch with proper lubrication, but in ordinary practice should never exceed 500 lbs. per square inch. The power consumed by friction is not increased by lengthening the bearings, and a wide bearing will wear longer and is easier to keep cool. In cases where the shaft has only its own weight to carry, the distance between bearings

may be expressed by the formula : $L = \sqrt[3]{(D \times 16)^2}$, in which D = diameter in inches, and L = length between bearings in feet.

PROPORTIONS OF KEYS FOR WHEELS AND PULLEYS

D = Diameter of shaft in inches.

B = Breadth of key in inches.

T = Thickness of key in inches.

d = Depth sunk in shaft, measured at side of key.

d′ = Depth sunk in boss of wheel, measured at side of key.

$\frac{D}{4} + .125 = B.\ \frac{D}{11} + .16 = T.\ \frac{D}{40} + .075 = d.\ T - d = d'.$

The key should be of equal breadth the whole length, but should taper in thickness about ⅛ inch to the foot in length. The same taper should be given to the key seat in the boss of the wheel, but not to the key bed in shaft.

RULE FOR CALCULATING SIZE AND SPEED OF PULLEYS

In calulating the speed and size of pulleys, it should be remembered that the diameter of the driving pulley, multiplied by its number of revolutions, is equal to the diameter of the receiving pulley multiplied by its number of revolutions. Therefore, the following rules may be easily remembered :

$$\frac{\text{Diam. driving pulley} \times \text{rev. per min.}}{\text{diam. receiving pulley}} = \left\{ \begin{array}{l}\text{rev. per min.}\\ \text{receiv'g pulley.}\end{array}\right.$$

$$\frac{\text{Diam. driving pulley} \times \text{rev. per min.}}{\text{rev. per min. receiving pulley}} = \left\{ \begin{array}{l}\text{diam. receiving}\\ \text{pulley.}\end{array}\right.$$

$$\frac{\text{Diam. receiv'g pulley} \times \text{rev. per min.}}{\text{diameter driving pulley}} = \left\{ \begin{array}{l}\text{rev. per min.}\\ \text{driving pulley.}\end{array}\right.$$

$$\frac{\text{Diam. receiv'g pulley} \times \text{rev. per min.}}{\text{rev. per min. driving pulley}} = \left\{ \begin{array}{l}\text{diam. driving}\\ \text{pulley.}\end{array}\right.$$

HORSE POWER OF BELTING

A simple rule for ascertaining transmitting power of belting, without first computing speed per minute that it travels, is as follows: Multiply diameter of pulley in inches by its number of revolutions per minute, and this product by width of the belt in inches; divide this product by 3300 for single belting, or by 2100 for double belting, and the quotient will be the amount of horse power that can be safely transmitted.

Table for Single Leather, Four-ply Rubber and Four-ply Cotton Belting, Belts not Overloaded

One inch wide, 800 feet per minute = One Horse Power.

Speed in Feet per Minute	Width of Belts in Inches											
	2	3	4	5	6	8	10	12	14	16	18	20
	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P	H.P.	H.P.	H.P.	H.P.	H.P.
400	1	1½	2	2½	3	4	5	6	7	8	9	10
600	1½	2¼	3	3¾	4½	6	7½	9	10½	12	13½	15
800	2	3	4	5	6	8	10	12	14	16	18	20
1000	2½	3¾	5	6¼	7½	10	12½	15	17½	20	22½	25
1200	3	4½	6	7½	9	12	15	18	21	24	27	30
1500	3¾	5¾	7½	9½	11½	15	18¾	22½	26½	30	33¾	37½
1800	4½	6¾	9	11¼	13½	18	22½	27	31½	36	40½	45
2000	5	7½	10	12½	15	20	25	30	35	40	45	50
2400	6	9	12	15	18	24	30	36	42	48	54	60
2800	7	10½	14	17½	21	28	35	42	49	56	63	70
3000	7½	11¼	15	18¾	22½	30	37½	45	52½	60	67½	75
3500	8¾	13	17½	22	26	35	44	52½	61	70	79	88
4000	10	15	20	25	30	40	50	60	70	80	90	100
4500	11¼	17	22½	28	34	45	57	69	78	90	102	114
5000	12½	19	25	31	37½	50	62½	75	87½	100	112	125

Double leather, six-ply rubber, or six-ply cotton belting will transmit 50 to 75 per cent. more power than is shown in this table. (One inch wide, 550 feet per minute = one horse power.)

SUNDRY TABLES

OF

WEIGHTS

AND

DIMENSIONS

WEIGHTS OF STEEL PLATES

PER SQUARE FOOT

U. S. Standard July 1, 1893	American	English	Decimals	Inches	Steel
	Brown & Sharpe	Stubbs or Birmingham			
	36	35	.005		.204
	35		.006		.245
36	34	34	.007		.286
35	32	33	.008		.327
34	31	32	.009		.367
32	30	31	.010		.408
31	29		.011		.449
		30	.012		.490
30	28	29	.013		.531
29	27	28	.014		.571
28	26		.015625	1-64	.639
		27	.016		.653
27			.017		.694
	25	26	.018		.735
26			.019		.776
	24	25	.020		.817
25		24	.022		.898
	23		.023		.939
24	22	23	.025		1.021
23	21	22	.028		1.143
			.031		1.266
22			.03125	1-32	1.276
	20	21	.032		1.307
21			.034		1.388
		20	.035		1.429
	19		.036		1.470
20			.038		1.552
	18		.040		1.633
		19	.042		1.715
19			.044		1.797
	17		.045		1.837
			.046875	3-64	1.914
		18	.049		2.001
18			.050		2.042
	16		.051		2.082
17			.056		2.286
	15		.057		2.327

WEIGHTS OF STEEL PLATES—Continued

PER SQUARE FOOT

U. S. Standard July 1, 1893	American	English	Decimals	Inches	Steel
	Brown & Sharpe	Stubbs or Birmingham			
		17	.058		2.368
16			$.062^{5}$	1-16	2.551
	14		$.064^{084}$		2.616
		16	.065		2.654
15			.07		
	13		$.071^{961}$		2.938
		15	.072		2.939
14			$.078^{125}$	5-64	3.189
	12		$.080^{808}$		3.299
		14	.083		3.388
	11		$.090^{742}$		3.705
			$.093^{75}$	3-32	3.827
13			.094		
		13	.095		3.878
	10		$.101^{89}$		4.160
12		12	.109		4.450
			$.109^{375}$	7-64	4.465
	9		$.114^{43}$		4.672
		11	.12		4.899
11			.125	1-8	5.103
	8		$.128^{49}$		5.246
		10	.134		5.471
			$.140^{625}$	9-64	5.741
10			.141		
	7		$.144^{28}$		5.891
		9	.148		6.042
9			.156		
			$.156^{25}$	5-32	6.379
	6		$.162^{02}$		6.615
		8	.165		6.737
			$.171^{875}$	11-64	7.017
8			.172		
		7	.18		7.349
	5		$.181^{94}$		7.428
			$.187^{5}$	3-16	7.655
7			.188		
6		6	.203		8.288

WEIGHTS OF STEEL PLATES—Continued

PER SQUARE FOOT

U. S. Standard July 1, 1893	American: Brown & Sharpe	English: Stubbs or Birmingham	Decimals	Inches	Steel
			.203125	13-64	8.293
	4		.20431		8.342
			.21875	7-32	8.931
5			.219		
		5	.22		8.982
	3		.22942		9.367
4			.234		
			.234375	15-64	9.569
		4	.238		9.717
			.244918		10.000
3			.250	1-4	10.207
	2		.25763		10.519
		3	.259		10.575
			.265625	17-64	10.845
2			.266		
1			.281		
			.28125	9-32	11.483
		2	.284		11.595
	1		.2893		11.812
			.296875	19-64	12.121
		1	.300		12.249
			.3125	5-16	12.759
0			.313		
	0		.32486		13.264
			.328125	21-64	13.397
		0	.34		13.882
			.34375	11-32	14.035
00			.344		
			.359375	23-64	14.673
	00		.3648		14.894
			.3673		14.996
000			.375	3-8	15.311
		00	.38		15.515
			.390625	25-64	15.949
0000			.406		
			.40625	13-32	16.587
	000		.40964		16.725

WEIGHTS OF STEEL PLATES—Continued

PER SQUARE FOOT

U. S. Standard July 1, 1893	American Brown & Sharpe	English Stubbs or Birmingham	Decimals	Inches	Steel
			$.421^{875}$	27-64	17.225
		000	.425		17.352
			$.437^{5}$	7-16	17.863
00000			.438		
			$.453^{125}$	29-64	18.501
		0000	.454		18.536
	0000		.46		18.781
			$.468^{75}$	15-32	19.139
000000			.469		
			$.484^{375}$	31-64	19.777
0000000		00000	.500	1-2	20.415
			$.515^{625}$	33-64	21.053
			$.531^{25}$	17-32	21.691
			$.546^{875}$	35-64	22.329
			$.562^{5}$	9-16	22.966
			$.578^{125}$	37-64	23.604
			$.593^{75}$	19-32	24.242
			$.609^{375}$	39-64	24.880
			.625	5-8	25.518
			$.640^{625}$	41-64	26.156
			$.656^{25}$	21-32	26.794
			$.671^{875}$	43-64	27.432
			$.687^{5}$	11-16	28.070
			$.703^{125}$	45-64	28.708
			$.718^{75}$	23-32	29.346
			$.734^{375}$	47-64	29.984
			.750	3-4	30.622
			$.765^{625}$	49-64	31.260
			$.781^{25}$	25-32	31.898
			$.796^{875}$	51-64	32.536
			$.812^{5}$	13-16	33.174
			$.828^{125}$	53-64	33.812
			$.843^{75}$	27-32	34.450
			$.859^{375}$	55-64	35.088
			.875	7-8	35.726
			$.890^{625}$	57-64	36.364
			$.906^{25}$	29-32	37.002

WEIGHTS OF STEEL PLATES—Continued

PER SQUARE FOOT

DECIMALS	INCHES	STEEL	DECIMALS	INCHES	STEEL
.921875	59-64	37.640	1.21875	1.7-32	49.761
.9375	15-16	38.278	1.23437	1.15-64	50.399
.953125	61-64	38.916	1.25	1.1-4	51.037
.96875	31-32	39.554	1.28125	1.9-32	52.313
.984375	63-64	40.192	1.3125	1.5-16	53.589
1.	1.	40.83	1.34375	1.11-32	54.865
1.01562	1.1-64	41.467	1.375	1.3-8	56.141
1.03125	1.1-32	42.106	1.40625	1.13-32	57.417
1.04687	1.3-64	42.744	1.4375	1.7-16	58.693
1.0625	1.1-16	43.381	1.46875	1.15-32	59.969
1.07812	1.5-64	44.019	1.5	1.1-2	61.245
1.09375	1.3-32	44.657	1.53125	1.17-32	62.521
1.10937	1.7-64	45.295	1.5625	1.9-16	63.796
1.125	1.1-8	45.933	1.59375	1.19-32	65.072
1.14062	1.9-64	46.571	1.625	1.5-8	66.348
1.15625	1.5-32	47.209	1.65625	1.21-32	67.624
1.17187	1.11-64	47.847	1.6875	1.11-16	68.900
1.1875	1.3-16	48.485	1.71875	1.23-32	70.176
1.20312	1.13-64	49.123	1.75	1.3-4	71.452

NOTE.—This table is based upon the average weight of 1 cubic foot of Steel, as given by—

Haswell, ... 490.12
Nystrom, ... 489.80

In calculating total weights of Plates, a percentage must be added to the weight given in this table to allow for spring of Rolls, according to width and gauge of Plates. See Standard Specifications, table of allowance for overweight, page 44.

WEIGHT OF CIRCULAR PLATES OF STEEL

DIAMETER IN INCHES

Thickness	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
1/8	7	8	9	10	11	12	14	15	16	18	19	20	22	24	25	27	29	30	32	34
3/16	11	12	14	15	17	19	20	22	24	26	28	30	33	35	38	40	43	45	48	51
1/4	15	16	18	20	23	25	27	30	32	35	38	41	44	47	50	54	57	61	65	68
5/16	18	20	23	25	28	31	34	37	40	44	47	51	55	59	63	67	71	76	81	85
3/8	22	24	27	30	34	37	41	44	48	53	56	61	65	71	75	80	86	91	97	102
7/16	25	28	32	35	39	43	47	52	56	61	66	71	76	82	88	94	100	106	113	119
1/2	29	32	36	40	45	49	54	59	64	70	75	81	87	94	100	107	114	121	129	136

DIAMETER IN INCHES

Thickness	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55
1/8	36	38	40	42	45	47	49	52	54	56	59	62	64	67	70	. .	. .	. .	. .	. .
3/16	54	57	60	64	67	70	74	77	81	85	88	92	96	100	105	109	113	117	122	126
1/4	72	76	80	85	89	94	98	103	108	113	118	123	128	134	139	145	151	156	162	168
5/16	90	95	100	106	111	117	123	129	135	141	147	154	160	167	174	181	188	195	203	210
3/8	108	115	121	127	134	141	148	155	162	169	177	185	193	201	209	217	226	235	244	253
7/16	126	134	141	148	156	164	172	180	188	197	206	215	225	234	244	253	263	273	284	295
1/2	144	153	161	169	178	187	197	206	215	225	235	246	257	267	279	289	301	313	325	337
9/16	162	172	181	190	200	211	221	232	242	253	265	277	289	301	313	325	339	352	365	379
5/8	180	191	201	212	223	234	246	258	269	282	294	308	321	334	348	362	376	391	406	421
11/16	198	210	221	233	245	258	270	283	296	310	324	338	353	367	383	398	414	430	446	463
3/4	216	229	241	254	267	281	295	309	323	338	353	369	385	401	418	434	452	469	487	505

Extra weights to be added for wide plates. [See table of allowances on page 44.]

WEIGHT OF CIRCULAR PLATES OF STEEL

DIAMETER IN INCHES

Thickness	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75
3/16	131	136	141	145	150	155	161	166	171	177	182	188	193	199	205	211	217	223	226	235
1/4	175	181	187	194	200	207	214	221	228	235	243	250	257	265	273	281	289	297	305	313
5/16	218	226	234	242	250	259	268	276	285	294	303	313	322	331	341	351	361	371	381	391
3/8	262	272	281	291	301	311	321	332	342	353	364	375	386	398	409	421	433	445	458	470
7/16	305	317	328	339	351	362	375	387	399	412	425	438	450	464	477	491	505	519	534	548
1/2	349	362	375	387	401	414	428	442	456	471	485	500	515	530	545	561	577	593	610	626
9/16	393	407	421	436	451	466	482	497	513	529	546	563	579	596	613	631	649	667	686	704
5/8	436	453	468	484	501	518	535	553	570	588	607	625	643	663	682	702	722	742	763	783
11/16	480	498	515	533	551	569	589	608	627	647	667	688	708	729	750	772	794	816	839	861
3/4	524	543	562	581	601	621	642	663	684	706	728	750	772	795	818	842	866	890	915	939

DIAMETER IN INCHES

Thickness	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
3/16	241	248	254	260	267	273	280	288	294	302	309	316	323	331	338	345	358	362	369	377
1/4	322	330	339	348	356	365	374	384	393	402	412	422	431	441	451	461	471	482	492	503
5/16	402	413	423	434	445	457	468	479	491	503	515	527	539	551	564	576	589	602	615	628
3/8	482	495	508	521	534	548	561	575	589	603	618	632	647	661	677	692	707	722	738	754
7/16	563	578	593	608	623	639	655	671	687	704	721	738	755	771	789	807	825	843	861	879
1/2	643	660	678	695	713	731	749	767	786	805	824	843	863	882	902	922	943	963	984	1005
9/16	723	743	762	782	802	822	842	863	884	905	926	948	970	992	1015	1037	1060	1084	1107	1131
5/8	804	825	847	869	891	913	936	959	982	1006	1029	1054	1078	1102	1128	1153	1178	1204	1230	1256
11/16	884	908	932	956	980	1004	1029	1055	1080	1106	1132	1159	1186	1212	1240	1268	1296	1324	1353	1382
3/4	964	990	1016	1043	1069	1096	1123	1151	1179	1207	1235	1265	1294	1323	1353	1383	1414	1445	1476	1507
13/16	1045	1073	1101	1129	1158	1187	1217	1246	1277	1307	1338	1370	1402	1433	1466	1495	1532	1565	1599	1633
7/8	1125	1155	1186	1216	1247	1278	1310	1342	1375	1408	1441	1475	1509	1543	1579	1614	1649	1686	1722	1759
15/16	1205	1238	1270	1303	1336	1370	1404	1438	1473	1508	1544	1581	1617	1653	1691	1729	1767	1806	1845	1884
1	1286	1320	1355	1390	1425	1461	1497	1534	1571	1609	1647	1686	1725	1763	1804	1844	1885	1926	1968	2010

Extra weights to be added for wide plates. [See table of allowances on page 44.]

WEIGHT OF CIRCULAR PLATES OF STEEL

DIAMETER IN INCHES

Thickness	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115
1/4	513	524	535	546	557	568	579	591	602	614	626	637	649	662	673	686	693	711	724	736
5/16	641	654	668	682	696	710	724	739	753	768	782	797	812	827	842	857	873	889	904	920
3/8	769	785	801	818	835	852	869	886	903	921	939	956	974	992	1010	1028	1048	1066	1085	1104
7/16	897	916	935	954	974	994	1014	1034	1054	1074	1095	1116	1136	1158	1179	1200	1222	1244	1266	1288
1/2	1026	1047	1069	1091	1113	1136	1158	1182	1204	1228	1251	1275	1299	1323	1347	1372	1397	1422	1447	1473
9/16	1154	1178	1202	1227	1252	1278	1303	1329	1355	1381	1408	1434	1461	1488	1516	1543	1571	1599	1628	1657
5/8	1282	1309	1336	1363	1391	1420	1448	1477	1505	1534	1564	1593	1623	1653	1684	1715	1746	1777	1809	1841
11/16	1410	1440	1469	1500	1530	1562	1593	1624	1656	1688	1720	1753	1786	1819	1853	1886	1920	1955	1990	2025
3/4	1538	1570	1603	1636	1669	1704	1738	1772	1806	1841	1877	1912	1948	1984	2021	2058	2095	2133	2171	2209
13/16	1666	1701	1737	1772	1809	1846	1882	1919	1957	1994	2033	2071	2110	2149	2189	2229	2270	2310	2351	2393
7/8	1795	1832	1870	1908	1948	1988	2027	2067	2107	2148	2189	2231	2273	2315	2358	2401	2444	2488	2532	2577
15/16	1923	1963	2004	2045	2087	2130	2172	2214	2258	2302	2346	2390	2435	2480	2526	2572	2619	2666	2713	2761
1	2052	2095	2139	2183	2227	2272	2317	2363	2409	2455	2502	2550	2598	2646	2695	2744	2793	2844	2894	2945

DIAMETER IN INCHES

Thickness	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135
1/4	749	762	775	788	802	815	829	842	856	870	884	898	912	926	941	955	970	985	1000	1015
5/16	936	953	969	985	1002	1019	1036	1053	1070	1087	1105	1122	1140	1158	1176	1194	1213	1231	1250	1268
3/8	1124	1143	1163	1183	1203	1223	1243	1263	1284	1305	1326	1347	1368	1390	1411	1433	1455	1477	1500	1522
7/16	1311	1334	1357	1380	1403	1426	1450	1474	1498	1522	1547	1571	1596	1621	1646	1672	1698	1723	1750	1775
1/2	1498	1524	1550	1577	1604	1630	1657	1685	1712	1740	1768	1796	1824	1853	1882	1911	1940	1970	1999	2030
9/16	1686	1715	1744	1774	1804	1834	1864	1895	1926	1957	1989	2020	2052	2085	2117	2150	2183	2216	2249	2284
5/8	1873	1905	1938	1971	2005	2038	2072	2106	2140	2175	2210	2245	2280	2316	2352	2389	2425	2462	2499	2537
11/16	2060	2096	2132	2168	2205	2242	2279	2316	2354	2392	2431	2469	2508	2548	2587	2627	2668	2708	2749	2790
3/4	2247	2286	2326	2365	2406	2445	2486	2527	2568	2610	2652	2694	2736	2779	2822	2866	2910	2954	2999	3044
13/16	2435	2477	2519	2562	2606	2649	2693	2737	2782	2827	2872	2918	2964	3011	3058	3105	3153	3200	3249	3298
7/8	2622	2667	2713	2759	2807	2853	2900	2948	2996	3045	3093	3143	3192	3242	3293	3344	3395	3446	3499	3551
15/16	2809	2858	2907	2956	3007	3057	3107	3159	3210	3262	3315	3367	3420	3474	3528	3583	3638	3693	3749	3805
1	2997	3048	3101	3154	3208	3260	3314	3369	3424	3480	3535	3592	3649	3706	3764	3822	3880	3939	3999	4059

Extra weights to be added for wide plates. [See table of allowances on page 44.]

WEIGHT AND SPECIFIC GRAVITY OF VARIOUS MATERIALS

Name	Weight in Pounds		Specific Gravity
	Per Cu. Ft.	Per Cu. In.	
Water, Pure, 60° F.	62.3	.036	1.00
" Sea, . . .	64.3	.037	1.03
METALS			
Iron, Cast, ...	450	.260	7.20
" Wrought, .	480	.277	7.69
Steel, ...	490	.283	7.84
Aluminum, . . .	166	.096	2.67
Brass, ...	524	.303	8.40
Bronze, ...	534	.309	8.56
Copper, ...	548	.317	8.80
Gold, ...	1208	.697	19.36
Lead, ...	710	.410	11.38
Platinum, ...	1344	.775	21.53
Silver, ...	655	.379	10.50
Tin, ...	458	.265	7.35
Zinc, ...	437	.252	7.00
MINERALS			
Asphalt, ...	87	.050	1.40
Brick, Soft, . .	100	.058	1.60
" Hard, . . .	125	.072	2.00
" Pressed, . .	150	.087	2.40
Brickwork, Ord'y,	112	.065	1.80
" Fine,	140	.081	2.24
Clay, ...	119	.068	1.92
Coal, Anthracite, .	93	.054	1.49
" Bituminous,	84	.048	1.35
Coke, Loose, . . .	27	.016	0.43
Concrete, Cement,	130	.075	2.09
Earth, from . . .	90	.052	1.44
" to	135	.078	2.17
Felspar, ...	166	.096	2.65
Flint, ...	162	.093	2.60

Name	Weight in Pounds		Specific Gravity
	Per Cu. Ft.	Per Cu. In.	
Glass, Crown, .	157	.090	2.52
" Plate, . .	172	.099	2.76
" Flint, . .	192	.111	3.08
Granite, ...	170	.098	2.73
Gypsum, ...	142	.082	2.28
Lime, Quick, . .	53	.030	0.85
Limestone, . . .	168	.097	2.70
Marl, ...	119	.068	1.92
Masonry, from .	138	.080	2.21
" to . .	165	.095	2.64
Mortar, average,	103	.059	1.65
Mud, ...	102	.059	1.63
Petroleum, . . .	55	.032	0.88
Plumbago, . . .	140	.081	2.24
Sand, average, .	100	.058	1.60
Sandstone, . . .	151	.087	2.42
Shale, ...	162	.094	2.60
Slate, ...	175	.101	2.80
Trap, ...	187	.108	3.00
WOODS			
Apple, ...	49	.028	0.78
Ash, ...	38	.022	0.61
Cedar, ...	37	.021	0.59
Cherry, ...	42	.024	0.67
Chestnut, . . .	41	.023	0.66
Hemlock, . .	25	.014	0.40
Maple, ...	49	.028	0.78
Oak, White, . .	50	.029	0.80
" Red, . .	45	.026	0.72
Pine, White, . .	25	.014	0.40
" Yellow, .	35	.020	0.56
Walnut, ...	38	.022	0.61

STRENGTH OF WROUGHT IRON BOLTS

(COMPUTED BY A. F. NAGLE)

Diameter of Bolt, Inches	Number of Threads	Diameter of Bottom of Thread, Inches	Area at Bottom of Thread, Square Inches	Stress upon Bolt upon Basis of working strength of 3000 Lbs. per Sq. Inch	4000 Lbs. per Sq. Inch	5000 Lbs. per Sq. Inch	7000 Lbs. per Sq. Inch	10000 Lbs. per Sq. Inch	Probable Breaking Load
				Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1/2	13	.38	.12	350	460	580	810	1160	5800
9/16	12	.44	.15	450	600	750	1050	1500	7500
5/8	11	.49	.19	560	750	930	1310	1870	9000
3/4	10	.60	.28	750	1130	1410	1980	2830	14000
7/8	9	.71	.39	1180	1570	1970	2760	3940	19000
1	8	.81	.52	1550	2070	2600	3630	5180	25000
1 1/8	7	.91	.65	1950	2600	3250	4560	6510	30000
1 1/4	7	1.04	.84	2520	3360	4200	5900	8410	39000
1 3/8	6	1.12	1.00	3000	4000	5000	7000	10000	46000
1 1/2	6	1.25	1.23	3680	4910	6140	8600	12280	56000
1 5/8	5 1/2	1.35	1.44	4300	5740	7180	10000	14360	65000
1 3/4	5	1.45	1.65	4950	6600	8250	11560	16510	74000
1 7/8	5	1.57	1.95	5840	7800	9800	13640	19500	85000
2	4 1/2	1.66	2.18	6540	8720	10900	15260	21800	95000
2 1/4	4 1/2	1.92	2.88	8650	11530	14400	20180	28800	125000
2 1/2	4	2.12	3.55	10640	14200	17730	24830	35500	150000
2 3/4	4	2.37	4.43	13290	17720	22150	31000	44300	186000
3	3 1/2	2.57	5.20	15580	20770	26000	36360	52000	213000
3 1/2	3 1/4	3.04	7.25	21760	29000	36260	50760	72500	290000
4	3	3.50	9.62	28860	38500	48100	67350	96200	385000

WEIGHT OF BOLTS PER HUNDRED

SQUARE HEADS AND NUTS

DIAM.	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2	1 3/4	2″
LENGTH	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1 1/2″	3.4	6.0	9.2	13.6	19.1	26.0	33.8	55.3	83.4	118.0	170.5	230.3	. . .	. . .	. . .	. . .
2″	4.1	7.1	10.8	15.7	21.8	29.5	38.1	61.5	91.8	129.0	184.5	247.5	. . .	. . .	. . .	. . .
2 1/2″	4.8	8.2	12.3	17.8	24.6	33.0	42.4	67.7	99.7	140.1	198.4	264.8	. . .	. . .	. . .	. . .
3″	5.5	9.2	13.8	19.9	27.4	36.5	46.7	73.9	108.1	151.1	212.4	282.0	350	480	. . .	. . .
3 1/2″	6.2	10.2	15.3	21.8	29.8	40.0	51.0	80.1	116.6	162.2	226.4	299.3	370	500	. . .	. . .
4″	6.9	11.4	16.9	24.0	32.6	43.5	55.4	86.3	125.0	173.2	240.4	316.6	390	520	800	. . .
4 1/2″	7.5	12.4	18.4	26.1	35.4	46.7	59.3	92.1	132.9	182.7	253.3	332.6	410	545	833	. . .
5″	8.2	13.5	19.9	28.2	38.1	50.2	63.6	98.3	141.3	193.7	267.3	349.9	430	570	866	1370
5 1/2″	8.9	14.6	21.5	30.3	40.9	53.7	67.9	104.5	149.8	204.8	281.2	367.1	450	595	900	1414
6″	9.6	15.6	23.0	32.4	43.7	57.2	72.3	110.7	158.2	215.8	295.2	384.4	470	620	934	1458
6 1/2″	10.3	16.7	24.6	34.5	46.4	60.7	76.6	116.9	166.7	226.9	309.2	401.6	490	645	968	1502
7″	11.0	17.8	26.1	36.6	49.2	64.2	80.9	123.1	175.1	237.9	323.2	418.9	510	670	1002	1546
7 1/2″	11.7	18.9	27.7	38.8	51.9	67.6	85.2	129.4	183.6	248.9	337.2	436.2	530	695	1036	1590
8″	12.4	20.0	29.2	40.9	54.7	71.1	89.5	135.6	192.0	260.0	351.1	453.4	550	725	1070	1634
9″	13.7	22.1	32.4	44.9	60.0	77.8	97.8	147.5	208.3	281.8	377.0	486.7	590	775	1138	1722
10″	15.1	24.3	35.5	49.1	65.5	84.8	106.4	160.0	225.2	303.3	404.9	521.2	630	825	1206	1810
11″	16.5	26.4	38.6	53.4	71.0	91.8	115.1	172.4	242.2	325.5	432.9	555.8	670	875	1274	1898
12″	17.9	28.6	41.7	57.6	76.5	98.8	123.7	184.8	259.1	347.6	460.8	590.3	710	925	1342	1986

WEIGHT OF BOLTS PER HUNDRED

SQUARE HEADS AND NUTS

DIAM.	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2	1 3/4	2″
LENGTH	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
13″	19.3	30.7	44.8	61.8	82.0	105.5	132 0	197.2	276.0	369.6	488.8	624.8	751	975	1410	2074
14″	20.6	32.9	47.9	66.0	87.6	112.5	140.6	209.7	292.0	391.7	516.7	659.3	793	1025	1478	2162
15″	22.0	35.1	51.0	70.3	93.1	119.5	149.2	222.1	309 8	413.8	544.7	693.8	835	1075	1548	2250
16″	23.4	37.2	54.1	74.5	98.6	126.4	157.9	234.5	326 7	435.9	572.7	728.3	877	1125	1616	2338
17″	24.8	39.4	57.2	78.7	104.1	133.4	166.5	246.9	343 6	458.0	600.6	762.8	919	1175	1684	2426
18″	26.2	41.5	60.3	82.9	109.7	140.4	175.1	259.4	360.5	480.1	628.6	797.4	961	1225	1752	2514
19″	27.5	43.7	63.4	87.2	115.2	147.4	183 7	271.8	377.5	502.2	656.5	831.9	1003	1275	1820	2602
20″	28.9	45.8	66.5	91.4	120.7	154.4	192.4	284.2	394.4	524.3	684.5	866.4	1045	1325	1888	2690
21″	30.3	48.0	69.6	95.6	126.2	161.4	201.0	296.6	411.3	546.4	712.4	900.9	1087	1375	1956	2778
22″	31.7	50.2	72.7	99.9	131.7	168.4	209.6	309.1	428.2	568.4	740.4	935.4	1129	1425	2024	2866
23″	33.1	52.3	75.8	104.1	137.3	175.4	218.3	321.5	445.1	590.5	768.3	969.9	1171	1475	2092	2954
24″	34.4	54.5	78.9	108.3	142 8	182.4	226.9	333.9	462.0	612.6	796.3	1004.5	1213	1525	2100	3042
25″	35.8	56.6	82.1	112.5	148.3	189.3	235.5	346.3	478.9	634.7	824.3	1039.0	1255	1575	2228	3130
26″	37.2	58.8	85.2	116.8	153.8	196.3	244.1	358.8	495.8	656.8	852.2	1073.5	1297	1625	2296	3218
27″	38.6	60.9	88.3	121.0	159.4	203.3	252.8	371.2	512.7	678.9	880.2	1108.0	1339	1675	2364	3306
28″	40.0	63.1	91.4	125.2	164.9	210.3	261.4	383.6	529.7	701.0	908.1	1142.5	1381	1725	2432	3394
29″	41.3	65.3	94.5	129.5	170.4	217.3	270.0	396.0	546.6	723.1	936.1	1177.0	1423	1775	2500	3482
30″	42.7	67.4	97.6	133.7	175.9	224.3	278.7	408.5	563.5	745.2	964.0	1211.5	1465	1825	2568	3570

CONE-HEAD IRON BOILER RIVETS
of Scant Diameter

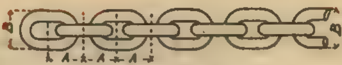
(Hoopes & Townsend Co.)

Weight per Hundred

Length in Inches	1/2	9/16	5/8	11/16	3/4	13/16	7/8	1
3/4	8.75	13.7	16.20	. . .	. . .	. . .	. .	. .
7/8	9.35	14.4	17.22	. . .	. . .	. . .	. .	. .
1	10.00	15.2	18.25	21.70	26.55	. . .	. .	. .
1 1/8	10.70	16.0	19.28	23.10	28.00	. . .	. .	. .
1 1/4	11.40	16.8	20.31	24.50	29.45	37.0	46	60
1 3/8	12.10	17.6	21.34	25.90	30.90	38.6	48	63
1 1/2	12.80	18.4	22.37	27.30	32.35	40.2	50	65
1 5/8	13.50	19.2	23.40	28.70	33.80	41.9	52	67
1 3/4	14.20	20.0	24.43	30.10	35.25	43.5	54	69
1 7/8	14.90	20.8	25.46	31.50	36.70	45.2	56	71
2	15.60	21.6	26.49	32.90	38.15	47.0	58	74
2 1/8	16.30	22.4	27.52	34.30	39.60	48.7	60	77
2 1/4	17.00	23.2	28.55	35.70	41.05	50.3	62	80
2 1/2	18.40	24.8	30.61	38.50	43.95	53.5	66	86
2 3/4	19.80	26.4	32.67	41.30	46.85	56.8	70	92
3	21.20	28.0	34.73	44.10	49.75	60.0	74	98
3 1/4	22.60	29.7	36.79	46.90	52.65	63.3	78	103
3 1/2	24.00	31.5	38.85	49.70	55.55	66.5	82	108
3 3/4	25.40	33.3	40.91	52.50	58.45	69.8	86	113
4	26.80	35.2	42.97	55.30	61.35	73.0	90	118
4 1/4	28.20	36.9	45.03	58.10	64.25	76.3	94	124
4 1/2	29.60	38.6	47.09	60.90	67.15	79.5	98	130
4 3/4	31.00	40.3	49.15	63.70	70.05	82.8	102	136
5	32.40	42.0	51.21	66.50	72.95	86.0	106	142
5 1/4	33.80	43.7	53.27	69.20	75.85	89.3	110	148
5 1/2	35.20	45.4	55.33	72.00	78.75	92.5	114	154
5 3/4	36.60	47.1	57.39	74.80	81.65	95.7	118	160
6	38.00	48.8	59.45	77.60	84.55	99.0	122	166
6 1/2	40.80	52.0	63.57	83.30	90.35	105.5	130	177
7	43.60	55.2	67.69	88.90	96.15	112.0	138	188
Heads	5.50	8.40	11.50	13.20	18.00	23.0	29.0	38.0

Button-head rivets weigh approximately the same as cone-head rivets.

CRANE CHAINS



Dimension				"D. B. G." Special Crane			Crane		
Size of Chain Inches	Pitch A Approximately Inches	Weight per Foot in Pounds Approximately	Outside Width, B Inches	Proof Test Pounds	Average Breaking Strain Pounds	Ordinary Safe Load General Use Pounds	Proof Test Pounds	Average Breaking Strain Pounds	Ordinary Safe Load General Use Pounds
1/4	25/32	7/8	7/8	1932	3864	1288	1680	3360	1120
5/16	27/32	1	1 1/16	2898	5796	1932	2520	5040	1680
3/8	31/32	1 7/10	1 1/4	4186	8372	2790	3640	7280	2427
7/16	1 5/32	2	1 3/8	5796	11592	3864	5040	10080	3360
1/2	1 11/32	2 1/2	1 11/16	7728	15456	5182	6720	13440	4480
9/16	1 15/32	3 2/10	1 7/8	9660	19320	6440	8400	16800	5600
5/8	1 23/32	4 1/8	2 1/16	11914	23828	7942	10360	20720	6907
11/16	1 27/32	5	2 1/4	14490	28980	9660	12600	25200	8400
3/4	1 31/32	5 7/8	2 1/2	17388	34776	11592	15120	30240	10080
13/16	2 3/32	6 7/10	2 11/16	20286	40572	13524	17640	35280	11760
7/8	2 7/32	8	2 7/8	22484	44968	14989	20440	40880	13627
15/16	2 15/32	9	3 1/16	25872	51744	17248	23520	47040	15680
1	2 19/32	10 7/10	3 1/4	29568	59136	19712	26880	53760	17920
1 1/16	2 23/32	11 3/10	3 5/16	33264	66538	22176	30240	60480	20160
1 1/8	2 27/32	12 1/2	3 3/4	37576	75152	25050	34160	68320	22773
1 3/16	3 5/32	13 7/10	3 7/8	41888	83776	27925	38080	76160	25387
1 1/4	3 7/32	16	4 1/8	46200	92400	30800	42000	84000	28000
1 5/16	3 15/32	16 1/2	4 3/8	50512	101024	33674	45920	91840	30613
1 3/8	3 5/8	18 4/10	4 9/16	55748	111496	37165	50680	101360	33787
1 7/16	3 25/32	19 7/10	4 3/4	60368	120736	40245	54880	109760	36587
1 1/2	3 31/32	21 7/10	5	66528	133056	44352	60480	120960	40320

The distance from centre of one link to centre of next is equal to the inside length of link, but in practice 1/32 inch is allowed for weld. This is approximate, and where exactness is required, chain should be made so.

For Chain Sheaves.—The diameter, if possible, should be not less than twenty times the diameter of chain used. *Example*—For 1-inch chain use 20-inch sheaves.

WEIGHT OF FLAT IRON

PER LINEAL FOOT

Width in Inches	Thickness in Inches									
	1/8	3/16	1/4	5/16	3/8	1/2	5/8	3/4	7/8	1
1/2	.208	.313	.417	.521	.625	. . .	. . .	. . .	. . .	. . .
5/8	.260	.390	.520	.650	.782	1.04	. . .	. . .	. . .	. . .
3/4	.313	.468	.625	.782	.937	1.25	1.56	. . .	. . .	. . .
7/8	.365	.547	.730	.913	1.09	1.46	1.82	2.19	. . .	. . .
1	.417	.625	.835	1.04	1.25	1.67	2.08	2.50	2.92	. . .
1 1/8	.469	.700	.940	1.17	1.41	1.88	2.34	2.81	3.28	3.75
1 1/4	.521	.781	1.04	1.30	1.56	2.08	2.60	3.13	3.65	4.17
1 3/8	.574	.860	1.15	1.43	1.72	2.29	2.86	3.44	4.01	4.58
1 1/2	.625	.938	1.25	1.56	1.88	2.50	3.13	3.75	4.38	5.00
1 5/8	.677	1.02	1.35	1.69	2.03	2 71	3.38	4.06	4.74	5.42
1 3/4	.729	1.09	1.46	1.82	2.19	2.92	3.65	4.38	5.10	5.83
2	.833	1.25	1.67	2.08	2.50	3.33	4.17	5.00	5.83	6.67
2 1/4	.938	1.41	1.88	2.34	2.81	3.75	4.69	5.63	6.56	7.50
2 1/2	1.04	1.56	2.08	2.60	3.13	4.17	5.21	6.25	7.29	8.33
2 3/4	1.15	1.72	2.29	2.86	3.44	4.58	5.73	6.88	8.02	9.17
3	1.25	1.87	2.50	3.13	3.75	5.00	6.25	7.50	8.75	10.00
3 1/4	1.35	2.03	2.71	3.38	4.07	5.42	6.77	8.12	9.48	10.83
3 1/2	1.46	2.19	2.92	3.65	4.38	5.83	7.29	8.75	10.21	11.66
3 3/4	1.56	2.34	3.12	3.90	4.69	6.25	7.81	9.37	10.94	12 50
4	1.67	2.50	3.33	4.17	5.00	6.67	8.33	10.00	11.67	13.33
4 1/2	1.87	2.81	3.75	4.69	5.63	7.50	9.38	11.25	13.13	15.00
5	2.08	3.13	4.17	5.21	6.25	8.34	10.42	12.50	14.59	16.67
6	2.50	3.75	5.00	6.25	7.50	10.00	12.50	15.00	17.50	20.00

WEIGHT OF ROUND AND SQUARE IRON

PER LINEAL FOOT

Size in Inches	● Weight in Pounds	■ Weight in Pounds	Size in Inches	● Weight in Pounds	■ Weight in Pounds
$\frac{3}{16}$	.092	.117	$1\frac{3}{4}$	8.018	10.21
$\frac{7}{32}$	.125	.159	$1\frac{7}{8}$	9.204	11.72
$\frac{1}{4}$	.164	.208	2	10.47	13.33
$\frac{9}{32}$	.207	.264	$2\frac{1}{8}$	11.82	15.05
$\frac{5}{16}$	.256	.326	$2\frac{1}{4}$	13.25	16.88
$\frac{11}{32}$	.309	.394	$2\frac{3}{8}$	14.77	18.80
$\frac{3}{8}$	.368	.469	$2\frac{1}{2}$	16.36	20.83
$\frac{13}{32}$	.432	.550	$2\frac{5}{8}$	18.04	22.97
$\frac{7}{16}$	.501	.638	$2\frac{3}{4}$	19.80	25.21
$\frac{1}{2}$	.654	.833	$2\frac{7}{8}$	21.64	27.55
$\frac{9}{16}$	.828	1.055	3	23.56	30.00
$\frac{5}{8}$	1.023	1.302	$3\frac{1}{4}$	27.65	35.21
$\frac{11}{16}$	1.237	1.576	$3\frac{1}{2}$	32.07	40.83
$\frac{3}{4}$	1.473	1.875	$3\frac{3}{4}$	36.82	46.88
$\frac{13}{16}$	1.728	2.201	4	41.99	53.33
$\frac{7}{8}$	2.004	2.552	$4\frac{1}{4}$	47.29	60.21
$\frac{15}{16}$	2.301	2.930	$4\frac{1}{2}$	53.01	67.50
1	2.618	3.333	$4\frac{3}{4}$	59.07	75.21
$1\frac{1}{16}$	2.955	3.763	5	65.45	83.33
$1\frac{1}{8}$	3.313	4.219	$5\frac{1}{4}$	72.16	91.88
$1\frac{3}{16}$	3.692	4.701	$5\frac{1}{2}$	79.19	100.80
$1\frac{1}{4}$	4.091	5.208	$5\frac{3}{4}$	86.56	110.20
$1\frac{5}{16}$	4.510	5.742	6	94.25	120.0
$1\frac{3}{8}$	4.950	6.302	$6\frac{1}{2}$	110.6	140.8
$1\frac{7}{16}$	5.410	6.888	7	128.3	163.3
$1\frac{1}{2}$	5.890	7.500	$7\frac{1}{2}$	147.3	187.5
$1\frac{9}{16}$	6.392	8.138	8	167.6	213.3
$1\frac{5}{8}$	6.913	8.802	$8\frac{1}{2}$	189.2	240.8

Weight of Cold Rolled Steel Shafting, Piston Rods, Etc.

MADE TO STANDARD GAUGE

Round				Square	
Diam.	Weight per Foot	Diam.	Weight per Foot	Size	Weight per Foot
4½ in.	54.11	1⅝ in.	7.06	4 in.	54.42
4 7/16	52.62	1 9/16	6.52	3¾	47.84
4¼	48.26	1½	6.01	3½	41.67
4	42.75	1 15/32	5.60	3¼	35.92
3 15/16	41.04	1 7/16	5.52	3	30.61
3¾	37.57	1 13/32	5.26	2¾	25.72
3 11/16	36.40	1⅜	5.05	2½	21.26
3⅝	35.20	1 5/16	4.61	2¼	17.25
3½	32.73	1 17/64	4.24	2	13.60
3 7/16	31.58	1 26/100	4.20	1¾	10.41
3⅜	30.43	1¼	4.17	1⅝	8.98
3¼	28.22	1 2/10	3.86	1½	7.66
3 3/16	27.16	1 3/16	3.77	1⅜	6.43
3⅛	26.09	1⅛	3.38	1¼	5.31
3	24.05	1 3/32	3.20	1⅛	4.30
2 15/16	23.06	1 5/64	3.11	1 1/16	3.85
2⅞	22.09	1 1/16	3.02	1	3.40
2 13/16	21.15	1	2.68	15/16	2.99
2¾	20.21	31/32	2.52	⅞	2.60
2 11/16	19.31	15/16	2.35	13/16	2.25
2⅝	18.41	29/32	2.20	¾	1.92
2 9/16	17.55	⅞	2.05	11/16	1.61
2½	16.70	27/32	1.94	⅝	1.34
2 7/16	15.89	13/16	1.77	9/16	1.08
2⅜	15.07	¾	1.50	½	.850
2 5/16	14.35	11/16	1.26	7/16	.652
2¼	13.52	21/32	1.17	⅜	.479
2 3/16	12.80	⅝	1.05	5/16	.332
2⅛	12.07	9/16	.845	9/32	.270
2 1/16	11.35	½	.667	¼	.213
2	10.69	15/32	.586	. . .	. . . .
1 15/16	10.03	7/16	.511	. . .	. . . .
1⅞	9.39	43/100	.506	. . .	. . . .
1 13/16	8.78	⅜	.375	. . .	. . . .
1¾	8.18	5/16	.260	. . .	. . . .
1 11/16	7.61	¼	.167	. . .	. . . .

Minimum and Maximum Weights and Dimensions of Standard Angles

EQUAL LEGS

Thickness of Metal	Size	Area	Wt. per Foot
7/8	6 x 6	9.74	33.1
13/16	6 x 6	9.09	30.9
3/4	6 x 6	8.44	28.7
11/16	6 x 6	7.78	26.5
5/8	6 x 6	7.11	24.2
9/16	6 x 6	6.43	21.9
1/2	6 x 6	5.75	19.6
7/16	6 x 6	5.06	17.2
13/16	4 x 4	5.84	19.9
3/4	4 x 4	5.44	18.5
11/16	4 x 4	5.03	17.1
5/8	4 x 4	4.61	15.7
9/16	4 x 4	4.18	14.3
1/2	4 x 4	3.75	12.8
7/16	4 x 4	3.31	11.3
3/8	4 x 4	2.86	9.8
5/16	4 x 4	2.40	8.2
13/16	3½ x 3½	5.03	17.1
3/4	3½ x 3½	4.69	16.0
11/16	3½ x 3½	4.34	14.8
5/8	3½ x 3½	3.98	13.6
9/16	3½ x 3½	3.62	12.3
1/2	3½ x 3½	3.25	11.1
7/16	3½ x 3½	2.87	9.8
3/8	3½ x 3½	2.48	8.5
5/8	3 x 3	3.36	11.4
9/16	3 x 3	3.06	10.4
1/2	3 x 3	2.75	9.4
7/16	3 x 3	2.43	8.3
3/8	3 x 3	2.11	7.2

Thickness of Metal	Size	Area	Wt. per Foot
5/16	3 x 3	1.78	6.1
1/4	3 x 3	1.44	4.9
1/2	2½ x 2½	2.25	7.7
7/16	2½ x 2½	2.00	6.8
3/8	2½ x 2½	1.73	5.9
5/16	2½ x 2½	1.47	5.0
1/4	2½ x 2½	1.19	4.1
7/16	2 x 2	1.56	5.3
3/8	2 x 2	1.36	4.7
5/16	2 x 2	1.15	4.0
1/4	2 x 2	0.94	3.2
3/16	2 x 2	0.72	2.5
7/16	1¾ x 1¾	1.30	4.6
3/8	1¾ x 1¾	1.17	4.0
5/16	1¾ x 1¾	1.00	3.4
1/4	1¾ x 1¾	0.81	2.8
3/16	1¾ x 1¾	0.62	2.1
3/8	1½ x 1½	0.99	3.4
5/16	1½ x 1½	0.84	2.9
1/4	1½ x 1½	0.69	2.4
3/16	1½ x 1½	0.53	1.8
5/16	1¼ x 1¼	0.69	2.4
1/4	1¼ x 1¼	0.56	1.9
3/16	1¼ x 1¼	0.43	1.5
1/8	1¼ x 1¼	0.30	1.0
1/4	1 x 1	0.44	1.5
3/16	1 x 1	0.34	1.2
1/8	1 x 1	0.24	0.8
3/16	¾ x ¾	0.25	0.8
1/8	¾ x ¾	0.17	0.6

Angles vary only by 1/16 inch.

Minimum and Maximum Weights and Dimensions of Standard I-Beams

Depth of Beam in Inches	Weight per Foot					Flange Width		Web Thickness		Increase of Web and Flanges for each lb. Increase of Weight
	Min.	Coefficient of Strength for Minimum Weights	For every lb. Incr. in Weight of Beam add to Coefficient for Min. Wts.	Intermediate	Max.	Min.	Max.	Min.	Max.	
24	80.00	1855900	12600	Vary by 5 lbs., ...	100.00	7.00	7.25	.50	.75	.0123
20	65.00	1247600	10450	" " 5 "	75.00	6.25	6.40	.50	.65	.015
15	42.00	628300	7800	45 lbs. then vary by 5 lbs.	55.00	5.50	5.75	.41	.66	.020
12	31.50	383700	6300	. . . .	35.00	5.00	5.09	.35	.44	.025
10	25.00	260500	5200	Vary by 5 lbs., ...	40.00	4.66	5.10	.31	.75	.029
9	21.00	201300	4700	25 lbs. then vary by 5 lbs.	35.00	4.33	4.77	.29	.73	.033
8	18.00	151700	4200	Vary by 2½ lbs., ...	25.50	4.00	4.27	.27	.54	.037
7	15.00	110400	3600	" " 2½ " . .	20.00	3.66	3.87	.25	.46	.042
6	12.25	77500	3100	" " 2½ "	17.25	3.33	3.57	.23	.47	.049
5	9.75	51600	2600	" " 2½ "	14.75	3.00	3.29	.21	.50	.059
4	7.50	31800	2100	Vary by 1 lb., ...	10.50	2.66	2.88	.19	.41	.074
3	5.50	17600	1560	" " 1 "	7.50	2.33	2.52	.17	.36	.098

The above coefficients are based upon a fibre stress of 16,000 pounds per square inch, used for buildings.

For bridges coefficients should be taken at three-quarters of above amount. To find the distributed safe load in pounds a beam will carry in a given span, divide the coefficients given for size and weight beam by the length of span in feet. To find the coefficient of strength for a given equally distributed load and span, multiply the load in pounds by the span in feet between centres of supports. Beams having the load concentrated in middle of span will safely carry one-half the amount the same beam would carry if the load was equally distributed.

Minimum and Maximum Weights and Dimensions of Standard Channels

Depth of Channel in Inches	Weight per Foot: Min.	Weight per Foot: Coefficient of Strength for Minimum Weights	Weight per Foot: For every lb. Incr. in Weight of Channel add to Co-efficient for Min. Wts.	Weight per Foot: Intermediate	Weight per Foot: Max.	Flange Width: Min.	Flange Width: Max.	Web Thickness: Min.	Web Thickness: Max.	Increase of Web and Flanges for each lb. Increase of Weight
15	33.00	444500	7800	35 lbs. then vary by 5 lbs.	55.00	3.40	3.82	.40	.82	.020
12	20.50	227800	6300	25 " " " " 5 "	40.00	2.94	3.42	.28	.76	.025
10	15.00	142700	5200	Vary by 5 lbs., ...	35.00	2.60	3.18	.24	.82	.029
9	13.25	112200	4700	15 lbs. then vary by 5 lbs.	25.00	2.43	2.82	.23	.62	.033
8	11.25	86100	4200	Vary by 2½ lbs., ...	21.25	2.26	2.62	.22	.58	.037
7	9.75	66800	3600	" " 2½ "	19.75	2.09	2.51	.21	.63	.042
6	8.00	46200	3100	" " 2½ "	15.50	1.92	2.28	.20	.56	.049
5	6.50	31600	2600	" " 2½ "	11.50	1.75	2.04	.19	.48	.059
4	5.25	20200	2100	Vary by 1 lb., ...	7.25	1.58	1.73	.18	.33	.074
3	4.00	11600	1560	" " 1 "	6.00	1.41	1.60	.17	.36	.098

The above coefficients are based upon a fibre stress of 16,000 pounds per square inch, used for buildings. For bridges coefficients should be taken at three-quarters of above amount. To find the distributed safe load in pounds a beam will carry in a given span, divide the coefficients given for size and weight beam by the length of span in feet. To find the coefficient of strength for a given equally distributed load and span, multiply the load in pounds by the span in feet between centres of supports. Beams having the load concentrated in middle of span will safely carry one-half the amount the same beam would carry if the load was equally distributed.

WEIGHTS AND MEASURES

AVOIRDUPOIS OR COMMERCIAL WEIGHT

UNITED STATES AND BRITISH

Grains	Ounces	Pounds	Hundred-weight	Gross Tons
1.	0.002286	0.000143	0.00000128	0.000000176
437.5	1.	0.0625	0.00055804	0.00002790
7000.	16.	1.	0.0089286	0.0004464
784000.	1792.	112.	1.	0.05
5680000.	35840.	2240.	20.	1.

1 pound avoirdupois = 1.215278 pounds troy.
1 net ton = 2000 pounds = 0.892857 gross tons.
1 pound troy = 0.82286 pounds avoirdupois.

LINEAR MEASURE

UNITED STATES AND BRITISH

Inches	Feet	Yards	Rods	Miles
1.	0.08333	0.02778	0.0050505	0.00001578
12.	1.	0.33333	0.0606061	0.00018939
36.	3.	1.	0.1818182	0.00056818
198.	16.5	5.5	1.	0.003125
63360.	5280.	1760.	320.	1.

GUNTER'S CHAIN MEASURE

USED IN SURVEYING

1 link = 7.92 inches = 0.01 chain = 0.000125 mile.
1 chain = 100 links = 66 feet = 4 rods = 0.0125 mile.
1 mile = 80 chains = 8000 links.

SQUARE OR SURFACE MEASURE

UNITED STATES AND BRITISH

Sq. Ins.	Square Feet	Sq. Yards	Square Rods	Acres	Square Miles
1	0.006944	0.0007716	. . . . . .	. . . . . .	. . . . .
144	1.	0.111111	. . . . . .	. . . . . .	. . . . .
1296	9.	1.	0.03306	0.0002066	. . . . .
39204	272.25	30.25	1.	0.00625	0.00000977
6272640	43560.	4840.	160.	1.	0.0015625
	27878400.	3097600.	102400.	640.	1.

1 acre = 10 square chains.

CUBIC MEASURE

1728 cubic inches = 1 cubic foot,
27 cubic feet = 1 cubic yard = 46656 cubic inches,
1 cord wood = 4 ft. × 4 ft. × 8 ft. = 128 cubic feet,
1 perch of masonry = 16.5 ft. × 1.5 ft. × 1 ft. = 24.75 cubic feet, but is generally assumed to be 25 cubic feet.

DRY MEASURE

UNITED STATES ONLY

Struck Bush.	Pecks.	Quarts	Pints	Gallons	Cubic Inch
1	4	32.	64	8.	2150.4
	1	8.	16	2.	537.6
		1.	2	0.25	67.2
		0.5	1	0.125	33.6
		4.	8	1.	268.8

The United States standard unit for dry measure is the old English Winchester bushel, which contains 2150.42 cubic inches, or 1.2445 cubic feet.

The heaped bushel, the cone of which is 6 inches above the brim of the measure, contains 2747.7 cubic inches.

In New York a bushel contains 2218.2 cubic inches, or 1.2837 cubic feet, which is the same as the Imperial bushel of England. 33 English or Imperial bushels are equal to 34.04 Winchester or United States bushels.

LIQUID MEASURE

UNITED STATES ONLY

Cubic Inch	Pints	Quarts	Gallons	Barrels	Hogs-head
28.875	1.	0.5	0.125	0.003968	
57.75	2.	1.	0.25	0.007937	
231.	8.	4.	1.	0.031746	
7276.5	252.	126.	31.5	1.	0.5
14553.0	504.	252.	63.	2.	1.

The British Imperial gallon = 1.20032 U. S. gallons.

The United States standard unit for liquid measure is the gallon = 231 cu. in. = 8.33888 pounds, avoirdupois, of distilled water at 62° Fahr.

The English standard is the Imperial gallon = 277.2738 cu. in. = 10 pounds, avoirdupois, of distilled water at 62° Fahr.

NAUTICAL MEASURE

A knot or nautical mile = 1.1527 statute miles = 6086 feet = length of a minute of longitude of the earth at the equator, at the level of sea, as determined by U. S. Coast Survey.

3 knots = 1 league.

SHIPPING MEASURE

1 Register ton = 100 cubic feet.

1 U. S. Shipping ton = 40 cubic feet.

1 British Shipping ton = 42 cubic feet.

MEASURE OF WORK AND POWER

A unit of work = one foot-pound, or a pressure of one pound exerted through a space of one foot.

A British Thermal unit = 778 foot-pounds.

A Horse Power = { 33,000 foot-pounds per minute,
550 foot-pounds per second,
42.42 heat-units per minute,
0.707 heat-units per second,
746 watts,
0.746 kilowatt.

THE METRIC SYSTEM OF WEIGHTS AND MEASURES

In the **Metric System,** the **Meter** is the base of all the weights and measures which it employs.

The **Meter** is the primary unit of length and was intended to be one ten-millionth part of the distance, measured on a meridian of the earth, from the equator to the pole, and equals about 39.37 inches.

Upon the Meter are based the following primary units: the **Square Meter** the **Are,** the **Cubic Meter** or **Stere** the **Liter,** and the **Gram.**

The **Square Meter** or **Centare** is the unit of measure for small surfaces.

The **Are** is the unit of land measure; this is a square whose side is ten meters in length, and which contains one hundred square meters or centares.

The **Cubic Meter,** or **Stere,** is the unit of volume; this is a cube whose edge is one meter in length.

The **Liter** is the unit of capacity; this is the capacity of a cube whose edge is one tenth of a meter, that is, one decimeter in length.

The **Gram** is the unit of weight; this is the weight of distilled water at 4° centigrade, contained in a cube whose edge is the one hundredth part of a meter.

From these primary units the higher and lower orders of units are derived decimally as follows:

Scheme of the Weights and Measures of the Metric System

Ratios	Lengths	Surfaces	Volumes	Weights
1,000,000,	. . . .	. . . . . .	. . . .	Millier, or Tonneau
100,000.	. . . .	. . . . . .	. . . .	Quintal
10,000.	Myr'iameter	. . . . . .	. . . .	Myr'iagram
1,000.	Kil'ometer	. . . . . .	Kil'oliter	Kil'ogram, or Kilo
100.	Hec'tometer	Hect'are	Hec'toliter	Hec'togram
10.	Dek'ameter	. . . . . .	Dek'aliter	Dek'agram
1.	Meter	Are	Li'ter	Gram
0.1	Dec'imeter	. . . . . .	Dec'iliter	Dec'igram
0.01	Cen'timeter	Cen'tare	Cen'tiliter	Cen'tigram
0.001	Mil'limeter	. . . . . .	Mil'liliter	Mil'ligram

It will be seen, from this table, that *ten* millimeters equal *one* centimeter, *ten* centimeters equal *one* decimeter, and so on.

Multiples and sub-multiples of the units, **meter, liter,** and **gram** are expressed by the prefixes:

Deka = 10	Deci = 0.1
Hecto = 100	Centi = 0.01
Kilo = 1000	Milli = 0.001

ABBREVIATIONS COMMONLY IN USE

mm,	millimeter	m^2,	square meter
cm,	centimeter	km^2,	" kilometer
dm,	decimeter	mm^3,	cubic millimeter
m,	meter	cm^3 / cc	" centimeter
km,	kilometer	dm^3,	" decimeter
mm^2,	square millimeter	m^3,	" meter
cm^2,	" centimeter		. . . .
dm^2,	" decimeter		

a, are ; ha, hectare ; cl, centiliter ; l, liter ; hl, hectoliter ; s, stere ; mg, milligram ; cg, centigram ; g, gram ; kg, kilo, or kilogram ; t, tonneau, or metric ton.

METRIC AND U. S. CONVERSION TABLE

MEASURES OF LENGTH

METRIC TO U. S.

1 millimeter	=	0.03937 inch.
1 centimeter	=	0.3937 "
1 meter	=	39.37 inches.
1 "	=	3.2808 feet.
1 kilometer	=	0.6214 mile.

U. S. TO METRIC

1 inch	=	25.4 millimeters.
1 "	=	2.54 centimeters.
1 "	=	0.0254 meter.
1 foot	=	0.3048 "
1 mile	=	1.609 kilometers.

MEASURES OF SURFACE

METRIC TO U. S.

1 sq. millimeter	=	0.00155 sq. inch.
1 " centimeter	=	0.155 " "
1 " meter	=	10.764 " feet.
1 " "	=	1.196 " yards.
1 hectare	=	2.471 acres.
1 "	=	0.00386 sq. mile.
1 sq. kilometer	=	0.3861 " "

U. S. TO METRIC

1 sq. inch	=	645.14 sq. millimeters.
1 " "	=	6.452 " centimeters.
1 " foot	=	0.0929 " meter.
1 " yard	=	0.8361 " "
1 acre	=	0.4047 hectare.
1 " mile	=	259.00 hectares.
1 " "	=	2.59 sq. kilometers.

MEASURES OF VOLUME AND CAPACITY

METRIC TO U. S.

1 cu. centimeter	= 0.061	cu. inch.
1 " meter	= 35.316	" feet.
1 " "	= 1.308	" yards.
1 liter = 1 cu. decimeter	= 61.023	cu. inch.

LIQUID MEASURE

1 liter	= 1.0567	quarts.
1 "	= 0.2642	gallon.
1 cubic meter	= 264.17	gallons.

DRY MEASURE

1 liter	= 0.908	quart.
1 hectoliter	= 2.8375	bushels.

U. S. TO METRIC

1 cu. inch	= 16.39	cu. centimeters.
1 " foot	= 0.0283	" meter.
1 " yard	= 0.7645	" "
1 " foot	= 28.32	liters.

LIQUID MEASURE

1 quart	= 0.9463	liter.
1 gallon	= 3.7854	liters.
1 "	= 0.0038	cu. meter.

DRY MEASURE

1 quart	= 1.1013	liters.
1 bushel	= 0.3524	hectoliter.

WEIGHTS

METRIC TO U. S.

1 milligram	= 0.0154	grain.
1 gram	= 15.432	grains.
1 kilogram	= 2.2046	lbs. (avoir.)
1 metric ton	= 1.1023	net tons.
1 " "	= 0.9842	gross ton.

U. S. TO METRIC

1 grain	= 64.80	milligrams.
1 "	= 0.0648	gram.
1 lb. (avoir.)	= 0.4536	kilogram.
1 net ton	= 0.9076	metric ton.
1 gross ton	= 1.0161	" tons.

COMPOUND UNITS

METRIC TO UNITED STATES

1 kilogram per meter	=	0.6720 lb. per foot.
1 kilogram per sq. centimeter	=	14.223 lbs. per sq. inch.
1 kilogram per sq. meter	=	0.2048 lb. per sq. foot.
1 kilogram per cubic meter	=	0.0624 lb. per cubic ft.
1 kilogram-meter	=	7.233 foot-pounds.
1 chevel vapeur (metric H. P.)	=	0.986 horse-power.
1 kilo watt	=	1.340 " "
1 kilo per chevel	=	2.235 lbs. per H. P.

UNITED STATES TO METRIC

1 lb. per foot	=	1.4882 kilograms per meter.
1 lb. per sq. inch	=	0.0703 kilo per sq. centimeter.
1 lb. per sq. foot	=	4.8825 kilograms per sq. meter.
1 lb. per cubic foot	=	16.0184 kilos per cubic meter.
1 foot pound	=	0.1383 kilogram-meter.
1 horse-power	=	1.014 chevel vapeur (metric H. P.).
1 " "	=	0.746 kilo watt.
1 lb. per horse-power	=	0.447 kilo per chevel.

HEAT INTENSITY

$$\text{Temp. Centigrade} = \left(\text{temp. Fahr.} - 32^\circ\right)\frac{5}{9}.$$

$$\text{Temp. Fahrenheit} = \left(\text{temp. C.} \times \frac{9}{5}\right) + 32^\circ.$$

HEAT QUANTITY

A kilogram calorie	=	3.968 British thermal units.
A pound calorie	=	1.8 " " "
A British thermal unit	=	0.252 kilogram calorie.
A British thermal unit	=	0.555 pound calorie.

MECHANICAL, ELECTRICAL AND HEAT EQUIVALENTS

(H. W. LEONARD)

UNIT	EQUIVALENT VALUE IN OTHER UNITS
1 K. W. Hour =	1,000 watt hours. 1.34 horse-power hours. 2,654,200 ft.-lbs. 3,600,000 joules. 3,412 heat-units. 367,000 kilogram meters. 0.235 lb. carbon oxidized with perfect efficiency. 3.53 lbs. water evaporated from and at 212° F. 22.75 lbs. of water raised from 62° to 212° F.
1 H. P. Hour =	0.746 K. W. hour. 1,980,000 ft.-lbs. 2,545 heat-units. 273,740 k. g. m. 0.175 lb. carbon oxidized with perfect efficiency. 2.64 lbs. water evaporated from and at 212° F. 17.0 lbs. water raised from 62° F. to 212° F.
1 Kilowatt =	1,000 watts. 1.34 horse-power. 2,654,200 ft.-lbs. per hour. 44,240 ft.-lbs. per minute. 737.3 ft.-lbs. per second. 3,412 heat-units per hour. 56.9 heat-units per minute. 0.948 heat-unit per second. 0.2275 lb. carbon oxidized per hour. 3.53 lbs. water evaporated per hour from and at 212° F.

MECHANICAL, ELECTRICAL AND HEAT EQUIVALENTS—*Continued*

Unit	Equivalent Value in Other Units
1 H. P. =	746 watts. 0.746 K. W. 33,000 ft.-lbs. per minute. 550 ft.-lbs. per second. 2,545 heat-units per hour. 42.4 heat-units per minute. 0.707 heat-unit per second. 0.175 lb. carbon oxidized per hour. 2.64 lbs. water evaporated per hour from and at 212° F.
1 Joule =	1 watt second. 0.000000278 K. W. hour. 0.102 k. g. m. 0.0009477 heat-unit. 0.7373 ft.-lb.
1 Ft.-lb. =	1.356 joules. 0.1383 k. g. m. 0.000000377 K. W. hour. 0.001285 heat-unit. 0.0000005 H. P. hour.
1 Watt =	1 joule per second. 0.00134 H. P. 3.412 heat-units per hour. 0.7373 ft.-lb. per second. 0.0035 lb. water evaporated per hour. 44.24 ft.-lbs. per minute.
1 Watt per sq. in. =	8.19 heat-units per square foot per minute. 6371 ft.-lbs. per square foot per minute. 0.193 H. P. per square foot.

MECHANICAL, ELECTRICAL AND HEAT EQUIVALENTS—Continued

Unit	Equivalent Value in Other Units
1 Heat-unit =	1,055 watt seconds. 778 ft.-lbs. 107.6 kilogram meters. 0.000293 K. W. hour. 0.000393 H. P. hour. 0.0000688 lb. carbon oxidized. 0.001036 lb. water evaporated from and at 212° F.
1 Heat-unit per Sq. ft. per min. =	0.122 watt per square inch. 0.0176 K. W. per square foot. 0.0236 H. P. per square foot.
1 Kilogram Meter =	7.233 ft.-lbs. 0.00000365 H. P. hour. 0.00000272 K. W. hour. 0.0093 heat-unit.
1 lb. Carbon Oxidized with perfect Efficiency =	14,544 heat-units. 1.11 lbs. Anthracite coal oxidized. 2.5 lbs. dry wool oxidized. 21 cubic feet illuminating gas. 4.26 K. W. hours. 5.71 H. P. hours. 11,315,000 ft.-lbs. 15 lbs. of water evaporated from and at 212° F.
1 lb. Water Evaporated from and at 212° F. =	0.283 K. W. hour. 0.379 H. P. hour. 965.7 heat-units. 103,900 k. g. m. 1,019,000 joules. 751,300 ft.-lbs. 0.0664 lb. of carbon oxidized.

MISCELLANEOUS TABLES

OF

USEFUL INFORMATION

NUMBER OF GALLONS IN CYLINDRICAL CISTERNS AND TANKS

Diam. in Feet	Depth in Feet															
	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1½	66	79	...	...	...	...	...	...	...	...	...	...	...	...	...	...
2	117	141	164	188	212	235	...	...	...	...	...	...	...	...	...	...
2½	184	220	257	294	330	367	404	441	...	...	...	...	...	...	...	...
3	264	317	370	423	476	529	582	635	687	740	...	...	...	...	...	...
3½	360	432	504	576	648	720	792	864	936	1008	1080	1152	...	...	...	...
4	470	564	658	752	846	940	1034	1128	1222	1316	1410	1504	1598	1692	...	...
5	734	881	1028	1175	1322	1469	1616	1763	1909	2056	2203	2350	2497	2644	2791	2938
6	1058	1269	1481	1692	1904	2115	2327	2538	2750	2961	3173	3384	3596	3807	4019	4230
7	1439	1727	2015	2303	2591	2879	3167	3455	3742	4030	4318	4606	4894	5182	5470	5758
8	1880	2256	2632	3008	3384	3760	4136	4512	4888	5264	5640	6016	6392	6768	7144	7520
9	2379	2855	3331	3807	4283	4759	5235	5711	6187	6662	7138	7614	8090	8566	9042	9518
10	2938	3525	4113	4700	5288	5875	6463	7050	7638	8225	8813	9400	9988	10575	11163	11750
11	3555	4265	4976	5687	6398	7109	7820	8531	9242	9953	10664	11374	12085	12796	13507	14218
12	4230	5076	5922	6768	7614	8460	9306	10152	10998	11844	12690	13536	14383	15229	16075	16921
13	4964	5957	6950	7943	8936	9929	10922	11915	12908	13901	14894	15886	16879	17872	18865	19858
14	5758	6909	8061	9212	10364	11515	12667	13818	14970	16121	17273	18424	19576	20727	21879	23030
15	6610	7931	9253	10575	11897	13219	14541	15863	17185	18507	19828	21150	22472	23794	25116	26438
16	7520	9025	10529	12033	13537	15041	16545	18049	19553	21057	22561	24066	25570	27074	28578	30082
18	9518	11422	13325	15229	17132	19036	20939	22843	24747	26650	28554	30458	32361	34265	36168	38072
20	11751	14101	16451	18800	21151	23501	25851	28201	30551	22901	35252	37602	39952	42302	44652	47002
22	14218	17062	19905	22749	25592	28436	31280	34123	36967	39810	42654	45498	48341	51185	54028	56872
24	16921	20305	23687	27073	30457	33841	37225	40609	43993	47377	50761	54146	57530	60914	64298	67682
25	18360	22032	25704	29376	33048	36720	40392	44064	47736	51408	55080	58752	62424	66096	69768	73440
26	19858	23830	27801	31773	35744	39716	43688	47659	51631	55602	59574	63546	67517	71489	75460	79432
27	21415	25698	29981	34264	38547	42830	47113	51396	55679	59962	64245	68528	72811	77094	81377	85660
28	23031	27637	32243	36849	41456	46062	50668	55274	59881	64487	69093	73699	78305	82912	87518	92124
29	24705	29646	34587	39528	44469	49410	54351	59292	64233	69174	74115	79056	83997	88938	93879	98820
30	26438	31726	37014	42302	47589	52877	58165	63452	68740	74028	79316	84603	89891	95179	100466	105754

NUMBER OF GALLONS IN CYLINDRICAL CISTERNS AND TANKS

Diam. in Feet	Depth in Feet														
	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
1½	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
2½	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
3½	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
5	3084	3231	3378	3525	3672	3819	3966	4113	4259	4406	4553	4700	4847	4994	5141
6	4442	4653	4865	5076	5288	5499	5711	5922	6134	6345	6557	6768	6980	7191	7403
7	6045	6333	6621	6909	7197	7485	7773	8061	8349	8636	8924	9212	9500	9788	10076
8	7896	8272	8648	9024	9400	9776	10152	10528	10904	11280	11656	12032	12408	12784	13160
9	9994	10470	10946	11422	11897	12373	12849	13325	13801	14277	14753	15229	15705	16180	16656
10	12338	12925	13513	14100	14688	15275	15863	16450	17038	17625	18213	18800	19388	19975	20563
11	14929	15640	16351	17062	17773	18483	19194	19905	20616	21327	22038	22749	23460	24171	24882
12	17767	18613	19459	20305	21151	21997	22843	23689	24535	25381	26227	26073	27919	28765	29611
13	20851	21844	22837	23830	24823	25816	26809	27801	28794	29787	30780	31773	32766	33759	34752
14	24182	25333	26485	27636	28788	29939	31091	32242	33394	34545	35697	36848	38000	39151	40303
15	27760	29082	30404	31726	33048	34369	35691	37013	38335	39657	40979	42301	43623	44945	46267
16	31586	33090	34594	36098	37603	39107	40611	42115	43619	45123	46627	48131	49635	51139	52644
18	39976	41879	43773	45676	47580	49484	51387	53291	55194	57098	59002	60905	62809	64712	66616
20	49352	51702	54052	56402	58753	61103	63453	65803	68153	70503	72853	74203	76553	78903	81254
22	59716	62559	65403	68246	71090	73934	76777	79621	82464	85308	88152	90995	93839	96682	99526
24	71066	74450	77834	81218	84603	87987	91371	94755	98139	101523	104907	108291	111675	115059	118444
25	77112	80784	84456	88128	91800	95472	99144	102816	106488	110160	113832	117504	121176	124848	128520
26	83404	87375	91347	95318	99290	103262	107233	111205	115176	119148	123120	127091	131063	135034	139006
27	89943	94226	98509	102792	107075	111358	115641	119924	124207	128490	132773	137056	141339	145622	149905
28	96730	101336	105943	110549	115155	119761	124367	128974	133580	138186	142792	147398	152005	156611	161217
29	103761	108702	113643	118584	123525	128466	133407	138348	143289	148230	153171	158112	163053	167994	172935
30	111042	116329	121617	126905	132193	137480	142768	148056	153343	158631	163919	169206	174494	179782	185070

Capacities of Rectan'l'r Tanks in U. S. Gals., for each Ft. in Depth = 1 Cu. Ft. = 7.4805 U. S. Gals. 1 Gal. = 231 Cu. Ins.

	Length																
Width	2′ 0″	2′ 6″	3′ 0″	3′ 6″	4′ 0″	4′ 6″	5′ 0″	5′ 6″	6′ 0″	6′ 6″	7′ 0″	7′ 6″	8′ 0″	8′ 6″	9′ 0″	9′ 6″	10′ 0″
2′ 0″	29.92	37.40	44.88	52.36	59.84	67.32	74.81	82.29	89.77	97.25	104.73	112.21	119.69	127.17	134.65	142.13	149.61
2′ 6″	. . .	46.75	56.10	65.45	74.80	84.16	93.51	102.86	112.21	121.56	130.91	140.26	149.61	158.96	168.31	177.66	187.01
3′ 0″	. . .	. . .	67.32	78.54	89.77	100.99	112.21	123.43	134.65	145.87	157.09	168.31	179.53	190.75	201.97	213.19	224.41
3′ 6″	. . .	. . .	. . .	91.64	104.73	117.82	130.91	144.00	157.09	170.18	183.27	196.36	209.45	222.54	235.63	248.73	261.82
4′ 0″	. . .	. . .	. . .	. . .	119.69	134.65	149.61	164.57	179.53	194.49	209.45	224.41	239.37	254.34	269.30	284.26	299.22
4′ 6″	. . .	. . .	. . .	. . .	. . .	151.48	168.31	185.14	201.97	218.80	235.63	252.47	269.30	286.13	302.96	319.79	336.62
5′ 0″	. . .	. . .	. . .	. . .	. . .	. . .	187.01	205.71	224.41	243.11	261.82	280.52	299.22	317.92	336.62	355.32	374.03
5′ 6″	. . .	. . .	. . .	. . .	. . .	. . .	. . .	226.28	246.86	267.43	288.00	308.57	329.14	349.71	370.28	390.85	411.43
6′ 0″	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	269.30	291.74	314.18	336.62	359.06	381.50	403.94	426.39	448.83
6′ 6″	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	316.05	340.36	364.67	388.98	413.30	437.60	461.92	486.23
7′ 0″	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	366.54	392.72	418.91	445.09	471.27	497.45	523.64
7′ 6″	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	420.78	448.83	476.88	504.93	532.98	561.04
8′ 0″	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	478.75	508.67	538.59	568.51	598.44
8′ 6″	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	540.46	572.25	604.05	635.84
9′ 0″	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	605.92	639.58	673.25
9′ 6″	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	675.11	710.65
10′ 0″	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	748.05
10′ 6″	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
11′ 0″	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
11′ 6″	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
12′ 0″	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
13′ 0″	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
14′ 0″	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
15′ 0″	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
16′ 0″	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
17′ 0″	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
18′ 0″	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
19′ 0″	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
20′ 0″	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
21′ 0″	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
22′ 0″	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
23′ 0″	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
24′ 0″	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
25′ 0″	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .

Capacities of Rectan'l'r Tanks in U. S. Gals., for each Ft. in Depth = 1 Cu. Ft. = 7.4805 U. S. Gals. 1 Gal. = 231 Cu. Ins.

Width	Length 10′ 6″	11′ 0″	11′ 6″	12′ 0″	13′ 0″	14′ 0″	15′ 0″	16′ 0″	17′ 0″	18′ 0″	19′ 0″	20′ 0″	21′ 0″	22′ 0″	23′ 0″	24′ 0″	25′ 0″
2′ 0″	157.09	164.57	172.05	179.53	194.49	209.45	224.42	239.38	254.34	269.30	284.26	299.22	314.18	329.14	344.10	359.06	374.03
2′ 6″	196.36	205.71	215.06	224.42	243.12	261.82	280.52	299.22	317.92	336.62	355.32	374.03	392.73	411.43	430.13	448.83	467.53
3′ 0″	235.63	246.86	258.07	269.30	291.74	314.18	336.62	359.06	381.51	403.95	426.39	448.83	471.27	493.71	516.15	538.60	561.04
3′ 6″	274.90	288.00	301.09	314.18	340.36	366.54	392.73	418.91	445.09	471.27	497.45	523.64	549.82	576.00	602.18	628.36	654.54
4′ 0″	314.18	329.14	344.10	359.06	388.99	418.91	448.83	478.75	508.67	538.60	568.52	598.44	628.36	658.28	688.21	718.13	748.05
4′ 6″	353.45	370.28	387.11	403.95	437.61	471.27	504.93	538.60	572.26	605.92	639.58	673.25	706.91	740.57	774.23	807.89	841.56
5′ 0″	392.72	411.43	430.13	448.83	486.23	523.64	561.04	598.44	635.84	673.25	710.65	748.05	785.45	822.85	860.26	897.66	935.06
5′ 6″	432.00	452.57	473.14	493.71	534.86	576.00	617.14	658.28	699.43	740.57	781.71	822.86	864.00	905.14	946.28	987.43	1028.6
6′ 0″	471.27	493.71	516.15	538.60	583.48	628.36	673.25	718.13	763.01	807.89	852.78	897.66	942.54	987.43	1032.3	1077.2	1122.1
6′ 6″	510.54	534.85	559.16	583.48	632.10	680.73	729.35	777.97	826.60	875.22	923.84	972.47	1021.1	1069.7	1118.3	1167.0	1215.6
7′ 0″	549.81	575.99	602.18	628.36	680.73	733.09	785.45	837.82	890.18	942.54	994.91	1047.3	1099.6	1152.0	1204.4	1256.7	1309.1
7′ 6″	589.08	617.14	645.19	673.25	729.35	785.45	841.56	897.66	953.77	1009.9	1066.0	1122.1	1178.2	1234.3	1290.4	1346.5	1402.6
8′ 0″	628.36	658.28	688.20	718.13	777.97	837.82	897.66	957.50	1017.3	1077.2	1137.0	1196.9	1256.7	1316.6	1376.4	1436.3	1496.1
8′ 6″	667.63	699.42	731.21	763.01	826.60	890.18	953.76	1017.3	1080.9	1144.5	1208.1	1271.7	1335.3	1398.9	1462.4	1526.0	1589.6
9′ 0″	706.90	740.56	774.23	807.89	875.22	942.54	1009.9	1077.2	1144.5	1211.8	1279.2	1346.5	1413.8	1481.1	1548.5	1615.8	1683.1
9′ 6″	746.17	781.71	817.24	852.78	923.84	994.91	1066.0	1137.0	1208.1	1279.2	1350.2	1421.3	1492.4	1563.4	1634.5	1705.6	1776.6
10′ 0″	785.45	822.86	860.26	897.66	972.47	1047.3	1122.1	1196.9	1271.7	1346.5	1421.3	1496.1	1570.9	1645.7	1720.5	1795.3	1870.1
10′ 6″	824.73	864.00	903.26	942.54	1021.1	1099.6	1178.2	1256.7	1335.3	1413.8	1492.4	1570.9	1649.5	1728.0	1806.5	1885.1	1963.6
11′ 0″	. . . .	905.14	946.27	987.43	1069.7	1152.0	1234.3	1316.6	1398.9	1481.1	1563.4	1645.7	1728.0	1810.3	1892.6	1974.9	2057.1
11′ 6″	. . . .	. . . .	989.29	1032.3	1118.3	1204.4	1290.4	1376.4	1462.4	1548.5	1634.5	1720.5	1806.5	1892.6	1978.6	2064.6	2150.6
12′ 0″	. . . .	. . . .	. . . .	1077.2	1167.0	1256.7	1346.5	1436.3	1526.0	1615.8	1705.6	1795.3	1885.1	1974.9	2064.6	2154.4	2244.2
13′ 0″	. . . .	. . . .	. . . .	. . . .	1264.2	1361.5	1458.7	1555.9	1653.2	1750.4	1847.7	1944.9	2042.2	2139.4	2236.7	2333.9	2431.2
14′ 0″	. . . .	. . . .	. . . .	. . . .	. . . .	1466.2	1570.9	1675.6	1780.4	1885.1	1989.8	2094.5	2199.3	2304.0	2408.7	2513.4	2618.2
15′ 0″	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	1683.1	1795.3	1907.5	2019.7	2131.9	2244.2	2356.4	2468.6	2580.8	2693.0	2805.2
16′ 0″	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	1915.0	2034.7	2154.4	2274.1	2393.8	2513.4	2633.1	2752.8	2872.5	2992.2
17′ 0″	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	2161.9	2289.0	2416.2	2543.4	2670.5	2797.7	2924.9	3052.0	3179.2
18′ 0″	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	2423.7	2558.3	2693.0	2827.6	2962.3	3096.9	3231.6	3366.2
19′ 0″	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	2700.5	2842.6	2984.7	3126.8	3269.0	3411.1	3553.2
20′ 0″	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	2992.2	3141.8	3291.4	3441.0	3590.6	3740.3
21′ 0″	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	3298.9	3456.0	3613.1	3770.2	3927.3
22′ 0″	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	3620.6	3785.1	3949.7	4114.3
23′ 0″	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	3957.2	4129.2	4301.3
24′ 0″	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	4308.8	4488.3
25′ 0″	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	4675.3

GALLONS AND CUBIC FEET

United States Gallons in a given Number of Cubic Feet

1 cubic foot = 7.480519 U. S. gallons; 1 gallon = 231 cu. in. = .13368056 cu. ft.

Cubic Ft.	Gallons	Cubic Ft.	Gallons	Cubic Ft.	Gallons
0.1	0.75	50	374.0	8,000	59,844.2
0.2	1.50	60	448.8	9,000	67,324.7
0.3	2.24	70	523.6	10,000	74,805.2
0.4	2.99	80	598.4	20,000	149,610.4
0.5	3.74	90	673.2	30,000	224,415.6
0.6	4.49	100	748.0	40,000	299,220.8
0.7	5.24	200	1,496.1	50,000	374,025.9
0.8	5.98	300	2,244.2	60,000	448,831.1
0.9	6.73	400	2,992.2	70,000	523,636.3
1	7.48	500	3,740.3	80,000	598,441.5
2	14.96	600	4,488.3	90,000	673,246.7
3	22.44	700	5,236.4	100,000	748,051.9
4	29.92	800	5,984.4	200,000	1,496,103.8
5	37.40	900	6,732.5	300,000	2,244,155.7
6	44.88	1,000	7,480.5	400,000	2,992,207.6
7	52.36	2,000	14,961.0	500,000	3,740,259.5
8	59.84	3,000	22,441.6	600,000	4,488,311.4
9	67.32	4,000	29,922.1	700,000	5,236,363.3
10	74.80	5,000	37,402.6	800,000	5,984,415.2
20	149.6	6,000	44,883.1	900,000	6,732,467.1
30	224.4	7,000	52,363.6	1,000,000	7,480,519.0
40	299.2				

Cubic Feet in a given Number of Gallons

Gallons	Cubic Ft.	Gallons	Cubic Ft.	Gallons	Cubic Ft.
1	.134	1,000	133.681	1,000,000	133,680.6
2	.267	2,000	267.361	2,000,000	267,361.1
3	.401	3,000	401.042	3,000,000	401,041.7
4	.535	4,000	534.722	4,000,000	534,722.2
5	.668	5,000	668.403	5,000,000	668,402.8
6	.802	6,000	802.083	6,000,000	802,083.3
7	.936	7,000	935.764	7,000,000	935,763.9
8	1.069	8,000	1,069.444	8,000,000	1,069,444.4
9	1.203	9,000	1,203.125	9,000,000	1,203,125.0
10	1.337	10,000	1,336.806	10,000,000	1,336,805.6

STANDARD GAUGES

No. of Gauge	Thickness in Decimals of an Inch							No. of Gauge
	Birmingham	Browne & Sharpe	Standard United States July 1, 1893	British Imperial	Washburn & Moen Co.	Trenton Iron Co.	Stubs Steel Wire	
7°	. . .	. . . .	.500	.500	. . . .	. . .	. .	7°
6°	. . .	. . . .	.46875	.464	. . . .	. . .	. .	6°
5°	. . .	. . . .	.4375	.432	. . . .	.45	. .	5°
4°	.454	.46	.40625	.400	.3938	.40	. .	4°
3°	.425	.40964	.375	.372	.3625	.36	. .	3°
2°	.380	.3648	.34375	.348	.3310	.33	. .	2°
0	.340	.32486	.3125	.324	.3065	.305	. .	0
1	.300	.2893	.28125	.300	.2830	.285	.227	1
2	.284	.25763	.265625	.276	.2625	.265	.219	2
3	.259	.22942	.25	.252	.2437	.245	.212	3
4	.238	.20431	.234375	.232	.2253	.225	.207	4
5	.220	.18194	.21875	.212	.2070	.205	.204	5
6	.203	.16202	.203125	.192	.1920	.190	.201	6
7	.180	.14428	.1875	.176	.1770	.175	.199	7
8	.165	.12849	.171875	.160	.1620	.160	.197	8
9	.148	.11443	.15625	.144	.1483	.145	.194	9
10	.134	.10189	.140625	.128	.1350	.130	.191	10
11	.120	.090742	.125	.116	.1205	.1175	.188	11
12	.109	.080808	.109375	.104	.1055	.1050	.185	12
13	.095	.071961	.09375	.092	.0915	.0925	.182	13
14	.083	.064084	.078125	.080	.0800	.0800	.180	14
15	.072	.057068	.0703125	.072	.0720	.0700	.178	15
16	.065	.05082	.0625	.064	.0625	.0610	.175	16
17	.058	.045257	.05625	.056	.0540	.0525	.172	17
18	.049	.040303	.05	.048	.0475	.0450	.168	18
19	.042	.03589	.04375	.040	.0410	.0400	.164	19
20	.035	.031961	.0375	.036	.0348	.0350	.161	20
21	.032	.028462	.034375	.032	.03175	.0310	.157	21
22	.028	.025347	.03125	.028	.0286	.0280	.155	22
23	.025	.022571	.028125	.024	.0258	.0250	.153	23
24	.022	.0201	.025	.022	.0230	.0225	.151	24
25	.020	.0179	.021875	.020	.0204	.0200	.148	25
26	.018	.01594	.01875	.018	.0181	.0180	.146	26
27	.016	.014195	.0171875	.0164	.0173	.0170	.143	27
28	.014	.012641	.015625	.0148	.0162	.0160	.139	28
29	.013	.011257	.0140625	.0136	.0150	.0150	.134	29
30	.012	.010025	.0125	.0124	.0140	.0140	.127	30
31	.010	.008928	.0109375	.0116	.0132	.0130	.120	31
32	.009	.00795	.01015625	.0108	.0128	.0120	.115	32
33	.008	.00708	.009375	.0100	.0118	.0110	112	33
34	.007	.006304	.00859375	.0092	.0104	.0100	.110	34
35	.005	.005614	.0078125	.0084	.0095	.0095	.108	35
36	.004	.005	.00703125	.0076	.0090	.0090	.106	36
37	. . .	.004453	.006640625	.0068	. . . .	.0085	.103	37
38	. . .	.003965	.00625	.0060	. . . .	.0080	.101	38
39	. . .	.003531	. . . . . .	. . .	. . . .	.0075	.099	39
40	. . .	.003144	. . . . . .	. . .	. . . .	.0070	.097	40

Proportions for U. S. Standard

SCREW THREADS AND NUTS

Diameter of Screw	Threads per Inch	Diameter at Root of Thread	Short Diameter of Nuts	Long Diameter, Hexagon Nuts	Long Diameter, Square Nuts	Thickness of Nuts
1/4	20	.185	1/2	37/64	45/64	1/4
5/16	18	.240	19/32	11/16	27/32	5/16
3/8	16	.294	11/16	51/64	63/64	3/8
7/16	14	.344	25/32	29/32	1 7/64	7/16
1/2	13	.400	7/8	1	1 15/64	1/2
9/16	12	.454	31/32	1 1/8	1 3/8	9/16
5/8	11	.507	1 1/16	1 7/32	1 1/2	5/8
3/4	10	.620	1 1/4	1 7/16	1 49/64	3/4
7/8	9	.731	1 7/16	1 21/32	2 1/32	7/8
1	8	.837	1 5/8	1 7/8	2 19/64	1
1 1/8	7	.940	1 13/16	2 3/32	2 9/16	1 1/8
1 1/4	7	1.065	2	2 5/16	2 53/64	1 1/4
1 3/8	6	1.160	2 3/16	2 17/32	3 3/32	1 3/8
1 1/2	6	1.284	2 3/8	2 3/4	3 23/64	1 1/2
1 5/8	5 1/2	1.389	2 9/16	2 31/32	3 5/8	1 5/8
1 3/4	5	1.491	2 3/4	3 3/16	3 57/64	1 3/4
1 7/8	5	1.616	2 15/16	3 13/32	4 5/32	1 7/8
2	4 1/2	1.712	3 1/8	3 5/8	4 27/64	2
2 1/4	4 1/2	1.962	3 1/2	4 1/16	4 61/64	2 1/4
2 1/2	4	2.176	3 7/8	4 1/2	5 31/64	2 1/2
2 3/4	4	2.426	4 1/4	4 29/32	6	2 3/4
3	3 1/2	2.629	4 5/8	5 3/8	6 17/32	3
3 1/4	3 1/2	2.879	5	5 3/4	7 1/16	3 1/4
3 1/2	3 1/4	3.100	5 3/8	6 13/64	7 39/64	3 1/2
3 3/4	3	3.317	5 3/4	6 21/32	8 1/8	3 3/4
4	3	3.567	6 1/8	7 3/32	8 41/64	4

DECIMALS OF AN INCH AND FOOT FOR EACH $\frac{1}{64}$

Fraction	$\frac{1}{32}$	$\frac{1}{64}$	Decimals of an Inch	Decimals of a Foot	Fraction	$\frac{1}{32}$	$\frac{1}{64}$	Decimals of an Inch	Decimals of a Foot
		1	.015625	.0013			33	.515625	.0430
	1		.031250	.0026		17		.531250	.0443
		3	.046875	.0039			35	.546875	.0456
$\frac{1}{16}$			.062500	.0052	$\frac{9}{16}$			.562500	.0469
		5	.078125	.0065			37	.578125	.0472
	3		.093750	.0078		19		.593750	.0495
		7	.109375	.0091			39	.609375	.0508
$\frac{1}{8}$			.125000	.0104	$\frac{5}{8}$			.625000	.0521
		9	.140625	.0117			41	.640625	.0534
	5		.156250	.0130		21		.656250	.0547
		11	.171875	.0143			43	.671875	.0560
$\frac{3}{16}$			.187500	.0156	$\frac{11}{16}$			.687500	.0573
		13	.203125	.0169			45	.703125	.0586
	7		.218750	.0182		23		.718750	.0599
		15	.234375	.0195			47	.734375	.0612
$\frac{1}{4}$			.250000	.0208	$\frac{3}{4}$			.750000	.0625
		17	.265625	.0221			49	.765625	.0638
	9		.281250	.0234		25		.781250	.0651
		19	.296875	.0247			51	.796875	.0664
$\frac{5}{16}$			.312500	.0260	$\frac{13}{16}$			.812500	.0677
		21	.328125	.0273			53	.828125	.0690
	11		.343750	.0286		27		.843750	.0703
		23	.359375	.0299			55	.859375	.0716
$\frac{3}{8}$			.375000	.0313	$\frac{7}{8}$			.875000	.0729
		25	.390625	.0326			57	.890625	.0742
	13		.406250	.0339		29		.906250	.0755
		27	.421875	.0352			59	.921875	.0768
$\frac{7}{16}$			.437500	.0365	$\frac{15}{16}$			.937500	.0781
		29	.453125	.0378			61	.953125	.0794
	15		.468750	.0391		31		.968750	.0807
		31	.484375	.0404			63	.984375	.0820
$\frac{1}{2}$			.500000	.0417	1			1.000000	.0833

DECIMALS OF A FOOT FOR EACH INCH

In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.
1	.0833	3	.2500	5	.4167	7	.5833	9	.7500	11	.9167
2	.1667	4	.3333	6	.5000	8	.6667	10	.8333	12	1.0000

PRODUCT OF FRACTIONS EXPRESSED IN DECIMALS

0	1	$\frac{1}{16}$	$\frac{1}{8}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{7}{8}$	$\frac{15}{16}$	1
$\frac{1}{16}$	.0625	.0039	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
$\frac{1}{8}$	.1250	.0078	.0156	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
$\frac{3}{16}$	.1875	.0117	.0234	.0351	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
$\frac{1}{4}$	.2500	.0156	.0313	.0469	.0625	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
$\frac{5}{16}$	.3125	.0195	.0391	.0587	.0781	.0977	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
$\frac{3}{8}$	.3750	.0234	.0469	.0705	.0937	.1172	.1406	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
$\frac{7}{16}$	.4375	.0273	.0547	.0823	.1093	.1367	.1641	.1914	. .	. .	. .	. .	. .	. .	. .	. .	. .
$\frac{1}{2}$	.5000	.0313	.0625	.0938	.1250	.1562	.1875	.2188	.2500	. .	. .	. .	. .	. .	. .	. .	. .
$\frac{9}{16}$	.5625	.0352	.0703	.1056	.1406	.1757	.2110	.2462	.2813	.3164	. .	. .	. .	. .	. .	. .	. .
$\frac{5}{8}$	.6250	.0391	.0781	.1172	.1562	.1952	.2343	.2734	.3125	.3516	.3906	. .	. .	. .	. .	. .	. .
$\frac{11}{16}$	.6875	.0430	.0859	.1289	.1718	.2148	.2578	.3007	.3438	.3867	.4297	.4727	. .	. .	. .	. .	. .
$\frac{3}{4}$	.7500	.0469	.0938	.1406	.1875	.2344	.2813	.3281	.3750	.4219	.4686	.5156	.5625	. .	. .	. .	. .
$\frac{13}{16}$	.8125	.0508	.1016	.1523	.2031	.2539	.3047	.3555	.4063	.4570	.5078	.5586	.6094	.6601	. .	. .	. .
$\frac{7}{8}$	.8750	.0547	.1094	.1640	.2187	.2734	.3281	.3828	.4375	.4922	.5469	.6016	.6563	.7109	.7656	. .	. .
$\frac{15}{16}$	.9375	.0586	.1172	.1757	.2343	.2929	.3515	.4102	.4688	.5274	.5859	.6445	.7031	.7617	.8203	.8789	. .
1	1.000	.0625	.1250	.1875	.2500	.3125	.3750	.4375	.5000	.5625	.6250	.6875	.7500	.8125	.8750	.9375	1.000

Number of Square Feet in Plates 3 to 32 Feet Long and 1 Inch Wide

For other widths, multiply by the width in inches.
1 sq. in. = .0069⅓ sq. ft.

Ft. and Ins. Long	Ins. Long	Square Feet	Ft. and Ins. Long	Ins. Long	Square Feet	Ft. and Ins. Long	Ins. Long	Square Feet
3. 0	36	.25	**7.** 0	84	.5834	**11.** 0	132	.9167
1	37	.2569	1	85	.5903	1	133	.9236
2	38	.2639	2	86	.5972	2	134	.9306
3	39	.2708	3	87	.6042	3	135	.9375
4	40	.2778	4	88	.6111	4	136	.9444
5	41	.2847	5	89	.6181	5	137	.9514
6	42	.2917	6	90	.625	6	138	.9583
7	43	.2986	7	91	.6319	7	139	.9653
8	44	.3056	8	92	.6389	8	140	.9722
9	45	.3125	9	93	.6458	9	141	.9792
10	46	.3194	10	94	.6528	10	142	.9861
11	47	.3264	11	95	.6597	11	143	.9931
4. 0	48	.3333	**8.** 0	96	.6667	**12.** 0	144	1.000
1	49	.3403	1	97	.6736	1	145	1.007
2	50	.3472	2	98	.6806	2	146	1.014
3	51	.3542	3	99	.6875	3	147	1.021
4	52	.3611	4	100	.6944	4	148	1.028
5	53	.3681	5	101	.7014	5	149	1.035
6	54	.375	6	102	.7083	6	150	1.042
7	55	.3819	7	103	.7153	7	151	1.049
8	56	.3889	8	104	.7222	8	152	1.056
9	57	.3958	9	105	.7292	9	153	1.063
10	58	.4028	10	106	.7361	10	154	1.069
11	59	.4097	11	107	.7431	11	155	1.076
5. 0	60	.4167	**9.** 0	108	.75	**13.** 0	156	1.083
1	61	.4236	1	109	.7569	1	157	1.09
2	62	.4306	2	110	.7639	2	158	1.097
3	63	.4375	3	111	.7708	3	159	1.104
4	64	.4444	4	112	.7778	4	160	1.114
5	65	.4514	5	113	.7847	5	161	1.118
6	66	.4583	6	114	.7917	6	162	1.125
7	67	.4653	7	115	.7986	7	163	1.132
8	68	.4722	8	116	.8056	8	164	1.139
9	69	.4792	9	117	.8125	9	165	1.146
10	70	.4861	10	118	.8194	10	166	1.153
11	71	.4931	11	119	.8264	11	167	1.159
6. 0	72	.5	**10.** 0	120	.8333	**14.** 0	168	1.167
1	73	.5069	1	121	.8403	1	169	1.174
2	74	.5139	2	122	.8472	2	170	1.181
3	75	.5208	3	123	.8542	3	171	1.188
4	76	.5278	4	124	.8611	4	172	1.194
5	77	.5347	5	125	.8681	5	173	1.201
6	78	.5417	6	126	.875	6	174	1.208
7	79	.5486	7	127	.8819	7	175	1.215
8	80	.5556	8	128	.8889	8	176	1.222
9	81	.5625	9	129	.8958	9	177	1.229
10	82	.5694	10	130	.9028	10	178	1.236
11	83	.5764	11	131	.9097	11	179	1.243

Square Feet in Plates—Continued

Ft. and Ins. Long	Ins. Long	Square Feet	Ft. and Ins. Long	Ins. Long	Square Feet	Ft. and Ins. Long	Ins. Long	Square Feet
15. 0	180	1.25	**19.** 4	232	1.611	**23.** 8	284	1.972
1	181	1.257	5	233	1.618	9	285	1.979
2	182	1.264	6	234	1.625	10	286	1.986
3	183	1.271	7	235	1.632	11	287	1.993
4	184	1.278	8	236	1.639	**24.** 0	288	2.
5	185	1.285	9	237	1.645	1	289	2.007
6	186	1.292	10	238	1.653	2	290	2.014
7	187	1.299	11	239	1.659	3	291	2.021
8	188	1.306	**20.** 0	240	1.667	4	292	2.028
9	189	1.313	1	241	1.674	5	293	2.035
10	190	1.319	2	242	1.681	6	294	2.042
11	191	1.326	3	243	1.688	7	295	2.049
16. 0	192	1.333	4	244	1.694	8	296	2.056
1	193	1.34	5	245	1.701	9	297	2.063
2	194	1.347	6	246	1.708	10	298	2.069
3	195	1.354	7	247	1.715	11	299	2.076
4	196	1.361	8	248	1.722	**25.** 0	300	2.083
5	197	1.368	9	249	1.729	1	301	2.09
6	198	1.375	10	250	1.736	2	302	2.097
7	199	1.382	11	251	1.743	3	303	2.104
8	200	1.389	**21.** 0	252	1.75	4	304	2.111
9	201	1.396	1	253	1.757	5	305	2.118
10	202	1.403	2	254	1.764	6	306	2.125
11	203	1.41	3	255	1.771	7	307	2.132
17. 0	204	1.417	4	256	1.778	8	308	2.139
1	205	1.424	5	257	1.785	9	309	2.146
2	206	1.431	6	258	1.792	10	310	2.153
3	207	1.438	7	259	1.799	11	311	2.16
4	208	1.444	8	260	1.806	**26.** 0	312	2.167
5	209	1.451	9	261	1.813	1	313	2.174
6	210	1.458	10	262	1.819	2	314	2.181
7	211	1.465	11	263	1.826	3	315	2.188
8	212	1.472	**22.** 0	264	1.833	4	316	2.194
9	213	1.479	1	265	1.84	5	317	2.201
10	214	1.486	2	266	1.847	6	318	2.208
11	215	1.493	3	267	1.854	7	319	2.215
18. 0	216	1.5	4	268	1.861	8	320	2.222
1	217	1.507	5	269	1.868	9	321	2.229
2	218	1.514	6	270	1.875	10	322	2.236
3	219	1.521	7	271	1.882	11	323	2.243
4	220	1.528	8	272	1.889	**27.** 0	324	2.25
5	221	1.535	9	273	1.896	1	325	2.257
6	222	1.542	10	274	1.903	2	326	2.264
7	223	1.549	11	275	1.91	3	327	2.271
8	224	1.556	**23.** 0	276	1.917	4	328	2.278
9	225	1.563	1	277	1.924	5	329	2.285
10	226	1.569	2	278	1.931	6	330	2.292
11	227	1.576	3	279	1.938	7	331	2.299
19. 0	228	1.583	4	280	1.944	8	332	2.306
1	229	1.59	5	281	1.951	9	333	2.313
2	230	1.597	6	282	1.958	10	334	2.319
3	231	1.604	7	283	1.965	11	335	2.326

Square Feet in Plates—Concluded

Ft. and Ins. Long	Ins. Long	Square Feet	Ft. and Ins. Long	Ins. Long	Square Feet	Ft. and Ins. Long	Ins. Long	Square Feet
28. 0	336	2.333	**29.** 5	353	2.451	**30.** 10	370	2.569
1	337	2.34	6	354	2.458	11	371	2.576
2	338	2.347	7	355	2.465	**31.** 0	372	2.583
3	339	2.354	8	356	2.472	1	373	2.59
4	340	2.361	9	357	2.479	2	374	2.597
5	341	2.368	10	358	2.486	3	375	2.604
6	342	2.375	11	359	2.493	4	376	2.611
7	343	2.382	**30.** 0	360	2.5	5	377	2.618
8	344	2.389	1	361	2.507	6	378	2.625
9	345	2.396	2	362	2.514	7	379	2.632
10	346	2.403	3	363	2.521	8	380	2.639
11	347	2.41	4	364	2.528	9	381	2.646
29. 0	348	2.417	5	365	2.535	10	382	2.653
1	349	2.424	6	366	2.542	11	383	2.66
2	350	2.431	7	367	2.549	**32.** 0	384	2.667
3	351	2.438	8	368	2.556	1	385	2.674
4	352	2.444	9	369	2.563	2	386	2.681

Circumferences and Areas of Circles

Advancing by Eighths

Diam.	Circum.	Area
1/64	.04909	.00019
1/32	.09818	.00077
3/64	.14726	.00173
1/16	.19635	.00307
3/32	.29452	.00690
⅛	.39270	.01227
5/32	.49087	.01917
3/16	.58905	.02761
7/32	.68722	.03758
¼	.78540	.04909
9/32	.88357	.06213
5/16	.98175	.07670
11/32	1.0799	.09281
⅜	1.1781	.11045
13/32	1.2763	.12962
7/16	1.3744	.15033
15/32	1.4726	.17257
½	1.5708	.19635
17/32	1.6690	.22166
9,16	1.7671	.24850
19/32	1.8653	.27688
⅝	1.9635	.30680
21/32	2.0617	.33824
11/16	2.1598	.37122
23/32	2.2580	.40574
¾	2.3562	.44179
25/32	2.4544	.47937
13/16	2.5525	.51849
27/32	2.6507	.55914
⅞	2.7489	.60132
29/32	2.8471	.64504
15/16	2.9452	.69029
31/32	3.0434	.73708
1.	3.1416	.7854
1/16	3.3379	.8866
⅛	3.5343	.9940
3/16	3.7306	1.1075
¼	3.9270	1.2272
5/16	4.1233	1.3530
⅜	4.3197	1.4849
7/16	4.5160	1.6230
½	4.7124	1.7671
9/16	4.9087	1.9175
⅝	5.1051	2.0739
11/16	5.3014	2.2365
¾	5.4978	2.4053
13/16	5.6941	2.5802

Diam.	Circum.	Area
1. ⅞	5.8905	2.7612
15/16	6.0868	2.9483
2.	6.2832	3.1416
1/16	6.4795	3.3410
⅛	6.6759	3.5466
3/16	6.8722	3.7583
¼	7.0686	3.9761
5/16	7.2649	4.2000
⅜	7.4613	4.4301
7/16	7.6576	4.6664
½	7.8540	4.9087
9/16	8.0503	5.1572
⅝	8.2467	5.4119
11/16	8.4430	5.6727
¾	8.6394	5.9396
13/16	8.8357	6.2126
⅞	9.0321	6.4918
15/16	9.2284	6.7771
3.	9.4248	7.0686
1/16	9.6211	7.3662
⅛	9.8175	7.6699
3/16	10.014	7.9798
¼	10.210	8.2958
5/16	10.407	8.6179
⅜	10.603	8.9462
7/16	10.799	9.2806
½	10.996	9.6211
9/16	11.192	9.9678
⅝	11.388	10.321
11/16	11.585	10.680
¾	11.781	11.045
13/16	11.977	11.416
⅞	12.174	11.793
15/16	12.370	12.177
4.	12.566	12.566
1/16	12.763	12.962
⅛	12.959	13.364
3/16	13.155	13.772
¼	13.352	14.186
5/16	13.548	14.607
⅜	13.744	15.033
7/16	13.941	15.466
½	14.137	15.904
9/16	14.334	16.349
⅝	14.530	16.800
11/16	14.726	17.257
¾	14.923	17.728
13/16	15.119	18.190
⅞	15.315	18.665
15/16	15.512	19.147

Diam.	Circum.	Area
5.	15.708	19.635
1/16	15.904	20.129
⅛	16.101	20.629
3/16	16.297	21.135
¼	16.493	21.648
5/16	16.690	22.166
⅜	16.886	22.691
7/16	17.082	23.221
½	17.279	23.758
9/16	17.475	24.301
⅝	17.671	24.850
11/16	17.868	25.406
¾	18.064	25.967
13/16	18.261	26.535
⅞	18.457	27.109
15/16	18.653	27.688
6.	18.850	28.274
⅛	19.242	29.465
¼	19.635	30.680
⅜	20.028	31.919
½	20.420	33.183
⅝	20.813	34.472
¾	21.206	35.785
⅞	21.598	37.122
7.	21.991	38.485
⅛	22.384	39.871
¼	22.776	41.282
⅜	23.169	42.718
½	23.562	44.179
⅝	23.955	45.664
¾	24.347	47.173
⅞	24.740	48.707
8.	25.133	50.265
⅛	25.525	51.849
¼	25.918	53.456
⅜	26.311	55.088
½	26.704	56.745
⅝	27.096	58.426
¾	27.489	60.132
⅞	27.882	61.862
9.	28.274	63.617
⅛	28.667	65.397
¼	29.060	67.201
⅜	29.452	69.029
½	29.845	70.882
⅝	30.238	72.760
¾	30.631	74.662
⅞	31.023	76.589
10.	31.416	78.540
⅛	31.809	80.516
¼	32.201	82.516

Circumferences and Areas of Circles—Continued

Diam.	Circum.	Area	Diam.	Circum.	Area	Diam.	Circum.	Area
10 3/8	32.594	84.541	17.	53.407	226.98	23 5/8	74.220	438.36
1/2	32.987	86.590	1/8	53.800	230.33	3/4	74.613	443.01
5/8	33.379	88.664	1/4	54.192	233.71	7/8	75.006	447.69
3/4	33.772	90.763	3/8	54.585	237.10	24.	75.398	452.39
7/8	34.165	92.886	1/2	54.978	240.53	1/8	75.791	457.11
11.	34.558	95.033	5/8	55.371	243.98	1/4	76.184	461.86
1/8	34.950	97.205	3/4	55.763	247.45	3/8	76.576	466.64
1/4	35.343	99.402	7/8	56.156	250.95	1/2	76.969	471.44
3/8	35.736	101.62	18.	56.549	254.47	5/8	77.362	476.26
1/2	36.128	103.87	1/8	56.941	258.02	3/4	77.754	481.11
5/8	36.521	106.14	1/4	57.334	261.59	7/8	78.147	485.98
3/4	36.914	108.43	3/8	57.727	265.18	25.	78.540	490.87
7/8	37.306	110.75	1/2	58.119	268.80	1/8	78.933	495.79
12.	37.699	113.10	5/8	58.512	272.45	1/4	79.325	500.74
1/8	38.092	115.47	3/4	58.905	276.12	3/8	79.718	505.71
1/4	38.485	117.86	7/8	59.298	279.81	1/2	80.111	510.71
3/8	38.877	120.28	19.	59.690	283.53	5/8	80.503	515.72
1/2	39.270	122.72	1/8	60.083	287.27	3/4	80.896	520.77
5/8	39.663	125.19	1/4	60.476	291.04	7/8	81.289	525.84
3/4	40.055	127.68	3/8	60.868	294.83	26.	81.681	530.93
7/8	40.448	130.19	1/2	61.261	298.65	1/8	82.074	536.05
13.	40.841	132.73	5/8	61.654	302.49	1/4	82.467	541.19
1/8	41.233	135.30	3/4	62.046	306.35	3/8	82.860	546.35
1/4	41.626	137.89	7/8	62.439	310.24	1/2	83.252	551.55
3/8	42.019	140.50	20.	62.832	314.16	5/8	83.645	556.76
1/2	42.412	143.14	1/8	63.225	318.10	3/4	84.038	562.00
5/8	42.804	145.80	1/4	63.617	322.06	7/8	84.430	567.27
3/4	43.197	148.49	3/8	64.010	326.05	27.	84.823	572.56
7/8	43.590	151.20	1/2	64.403	330.06	1/8	85.216	577.87
14.	43 982	153.94	5/8	64.795	334.10	1/4	85.608	583.21
1/8	44.375	156.70	3/4	65.188	338.16	3/8	86.001	588.57
1/4	44.768	159.48	7/8	65.581	342.25	1/2	86.394	593.96
3/8	45.160	162.30	21.	65.973	346.36	5/8	86.786	599.37
1/2	45.553	165.13	1/8	66.366	350.50	3/4	87.179	604.81
5/8	45.946	167.99	1/4	66.759	354.66	7/8	87.572	610.27
3/4	46.338	170.87	3/8	67.152	358.84	28.	87.965	615.75
7/8	46.731	173.78	1/2	67.544	363.05	1/8	88.357	621.26
15.	47.124	176.71	5/8	67.937	367.28	1/4	88.750	626.80
1/8	47.517	179.67	3/4	68.330	371.54	3/8	89.143	632.36
1/4	47.909	182 65	7/8	68.722	375.83	1/2	89.535	637.94
3/8	48.302	185.66	22.	69.115	380.13	5/8	89.928	643.55
1/2	48.695	188.69	1/8	69.508	384.46	3/4	90.321	649.18
5/8	49.087	191.75	1/4	69.900	388.82	7/8	90.713	654.84
3/4	49.480	194.83	3/8	70.293	393.20	29.	91.106	660.52
7/8	49.873	197.93	1/2	70.686	397.61	1/8	91.499	666.23
16.	50.265	201 06	5/8	71.079	402.04	1/4	91.892	671.96
1/8	50.658	204.22	3/4	71.471	406.49	3/8	92.284	677.71
1/4	51 051	207.39	7/8	71.864	410.97	1/2	92.677	683.49
3/8	51.444	210.60	23.	72.257	415.48	5/8	93.070	689.30
1/2	51.836	213.82	1/8	72.649	420.00	3/4	93.462	695.13
5/8	52.229	217.08	1/4	73.042	424.56	7/8	93.855	700 98
3/4	52.622	220.35	3/8	73.435	429.13	30.	94.248	706.86
7/8	53.014	223.65	1/2	73.827	433.74	1/8	94.640	712.76

Circumferences and Areas of Circles—Continued

Diam.	Circum.	Area	Diam.	Circum.	Area	Diam.	Circum.	Area
301/4	95.033	718.69	**36**7/8	115.846	1068.0	**43**1/2	136.659	1486.2
3/8	95.426	724.64	**37.**	116.239	1075.2	5/8	137.052	1494.7
1/2	95.819	730.62	1/8	116.632	1082.5	3/4	137.445	1503.3
5/8	96.211	736.62	1/4	117.024	1089.8	7/8	137.837	1511.9
3/4	96.604	742.64	3/8	117.417	1097.1	**44.**	138.230	1520.5
7/8	96.997	748.69	1/2	117.810	1104.5	1/8	138.623	1529.2
31.	97.389	754.77	5/8	118.202	1111.8	1/4	139.015	1537.9
1/8	97.782	760.87	3/4	118.596	1119.2	3/8	139.408	1546.6
1/4	98.175	766.99	7/8	118.988	1126.7	1/2	139.801	1555.3
3/8	98.567	773.14	**38.**	119.381	1134.1	5/8	140.194	1564.0
1/2	98.960	779.31	1/8	119.773	1141.6	3/4	140.586	1572.8
5/8	99.353	785.51	1/4	120.166	1149.1	7/8	140.979	1581.6
3/4	99.746	791.73	3/8	120.559	1156.6	**45.**	141.372	1590.4
7/8	100.138	797.98	1/2	120.951	1164.2	1/8	141.764	1599.3
32.	100.531	804.25	5/8	121.344	1171.7	1/4	142.157	1608.2
1/8	100.924	810.54	3/4	121.737	1179.3	3/8	142.550	1617.0
1/4	101.316	816.86	7/8	122.129	1186.9	1/2	142.942	1626.0
3/8	101.709	823.21	**39.**	122.522	1194.6	5/8	143.335	1634.9
1/2	102.102	829.58	1/8	122.915	1202.3	3/4	143.728	1643.9
5/8	102 494	835.97	1/4	123.308	1210.6	7/8	144.121	1652.9
3/4	102.887	842.39	3/8	123.700	1217.7	**46.**	144.513	1661.9
7/8	103.280	848.83	1/2	124.093	1225.4	1/8	144.906	1670.9
33.	103.673	855.30	5/8	124.486	1233.2	1/4	145.299	1680.0
1/8	104.065	861.79	3/4	124.878	1241.0	3/8	145.691	1689.1
1/4	104.458	868.31	7/8	125.271	1248.8	1/2	146.084	1698.2
3/8	104.851	874.85	**40.**	125.664	1256.6	5/8	146.477	1707.4
1/2	105.243	881.41	1/8	126.056	1264.5	3/4	146.869	1716.5
5/8	105.636	888 00	1/4	126.449	1272.4	7/8	147.262	1725.7
3/4	106.029	894.62	3/8	126.842	1280.3	**47.**	147.655	1734.9
7/8	106.421	901.26	1/2	127.235	1288.2	1/8	148.048	1744.2
34.	106.814	907.92	5/8	127.627	1296.2	1/4	148.440	1753.5
1/8	107.207	914.61	3/4	128.020	1304.2	3/8	148.833	1762.7
1/4	107.600	921.32	7/8	128.413	1312.2	1/2	149.226	1772.1
3/8	107.992	928.06	**41.**	128.805	1320.3	5/8	149.618	1781.4
1/2	108.385	934.82	1/8	129.198	1328.3	3/4	150.011	1790.8
5/8	108.778	941.61	1/4	129.591	1336.4	7/8	150.404	1800.1
3/4	109.170	948.42	3/8	129.983	1344.5	**48.**	150.796	1809.6
7/8	109.563	955.25	1/2	130.376	1352.7	1/8	151.189	1819.0
35.	109.956	962.11	5/8	130.769	1360.8	1/4	151.582	1828.5
1/8	110.348	969.00	3/4	131.161	1369.0	3/8	151.975	1837.9
1/4	110.741	975.91	7/8	131.554	1377.2	1/2	152.367	1847.5
3/8	111.134	982.84	**42.**	131.947	1385.4	5/8	152.760	1857.0
1/2	111.527	989.80	1/8	132.340	1393.7	3/4	153.153	1866.5
5/8	111.919	996.78	1/4	132.732	1402.0	7/8	153.545	1876.1
3/4	112.312	1003.8	3/8	133.125	1410.3	**49.**	153.938	1885.7
7/8	112.705	1010.8	1/2	133.518	1418.6	1/8	154.331	1895.4
36.	113.097	1017.9	5/8	133.910	1427.0	1/4	154.723	1905.0
1/8	113.490	1025.0	3/4	134.303	1435.4	3/8	155.116	1914.7
1/4	113.883	1032.1	7/8	134.696	1443.8	1/2	155.509	1924.4
3/8	114.275	1039.2	**43.**	135.088	1452.2	5/8	155.902	1934.2
1/2	114.668	1046.3	1/8	135.481	1460.7	3/4	156.294	1943.9
5/8	115.061	1053.5	1/4	135.874	1469.1	7/8	156.687	1953.7
3/4	115.454	1060.7	3/8	136.267	1477.6	**50.**	157.080	1963.5

Circumferences and Areas of Circles—Continued

Diam.	Circum.	Area	Diam.	Circum.	Area	Diam.	Circum.	Area
50⅛	157.472	1973.3	56¾	178.285	2529.4	63⅜	199.098	3154.5
¼	157.865	1983.2	⅞	178.678	2540.6	½	199.491	3166.9
⅜	158.258	1993.1	57.	179.071	2551.8	⅝	199.884	3179.4
½	158.650	2003.0	⅛	179.463	2563.0	¾	200.277	3191.9
⅝	159.043	2012.9	¼	179.856	2574.2	⅞	200.669	3204.4
¾	159.436	2022.8	⅜	180.249	2585.4	64.	201.062	3217.0
⅞	159.829	2032.8	½	180.642	2596.7	⅛	201.455	3229.6
51.	160.221	2042.8	⅝	181.034	2608.0	¼	201.847	3242.2
⅛	160.614	2052.8	¾	181.427	2619.4	⅜	202.240	3254.8
¼	161.007	2062.9	⅞	181.820	2630.7	½	202.633	3267.5
⅜	161.399	2073.0	58.	182.212	2642.1	⅝	203.025	3280.1
½	161.792	2083.1	⅛	182.605	2653.5	¾	203.418	3292.8
⅝	162.185	2093.2	¼	182.998	2664.9	⅞	203.811	3305.6
¾	162.577	2103.3	⅜	183.390	2676.4	65.	204.204	3318.3
⅞	162.970	2113.5	½	183.783	2687.8	⅛	204.596	3331.1
52.	163.363	2123.7	⅝	184.176	2699.3	¼	204.989	3343.9
⅛	163.756	2133.9	¾	184.569	2710.9	⅜	205.382	3356.7
¼	164.148	2144.2	⅞	184.961	2722.4	½	205.774	3369.6
⅜	164.541	2154.5	59.	185.354	2734.0	⅝	206.167	3382.4
½	164.934	2164.8	⅛	185.747	2745.6	¾	206.560	3395.3
⅝	165.326	2175.1	¼	186.139	2757.2	⅞	206.952	3408.2
¾	165.719	2185.4	⅜	186.532	2768.8	66.	207.345	3421.2
⅞	166.112	2195.8	½	186.925	2780.5	⅛	207.738	3434.2
53.	166.504	2206.2	⅝	187.317	2792.2	¼	208.131	3447.2
⅛	166.897	2216.6	¾	187.710	2803.9	⅜	208.523	3460.2
¼	167.290	2227.0	⅞	188.103	2815.7	½	208.916	3473.2
⅜	167.683	2237.5	60.	188.496	2827.4	⅝	209.309	3486.3
½	168.075	2248.0	⅛	188.888	2839.2	¾	209.701	3499.4
⅝	168.468	2258.5	¼	189.281	2851.0	⅞	210.094	3512.5
¾	168 861	2269.1	⅜	189.674	2862.9	67.	210.487	3525.7
⅞	169.253	2279.6	½	190.066	2874.8	⅛	210.879	3538.8
54.	169.646	2290.2	⅝	190.459	2886.6	¼	211.272	3552.0
⅛	170.039	2300.8	¾	190.852	2898.6	⅜	211.665	3565.2
¼	170.431	2311.5	⅞	191.244	2910.5	½	212.058	3578.5
⅜	170.824	2322.1	61.	191.637	2922.5	⅝	212.450	3591.7
½	171.217	2332.8	⅛	192.030	2934.5	¾	212.843	3605,0
⅝	171.609	2343.5	¼	192.423	2946.5	⅞	213.236	3618.3
¾	172.002	2354.3	⅜	192.815	2958.5	68.	213.628	3631.7
⅞	172.395	2365.0	½	193.208	2970.6	⅛	214.021	3645.0
55.	172.788	2375.8	⅝	193.601	2982.7	¼	214.414	3658.4
⅛	173.180	2386.6	¾	193.993	2994.8	⅜	214.806	3671.8
¼	173.573	2397.5	⅞	194.386	3006.9	½	215.199	3685.3
⅜	173.966	2408.3	62.	194.779	3019.1	⅝	215.592	3698.7
½	174.358	2419.2	⅛	195.171	3031.3	¾	215.984	3712.2
⅝	174.751	2430.1	¼	195.564	3043.5	⅞	216.377	3725.7
¾	175.144	2441.1	⅜	195.957	3055.7	69.	216.770	3739.3
⅞	175.536	2452.0	½	196.350	3068.0	⅛	217.163	3752.8
56.	175.929	2463.0	⅝	196.742	3080.3	¼	217.555	3766.4
⅛	176.322	2474.0	¾	197.135	3092.6	⅜	217.948	3780.0
¼	176.715	2485.0	⅞	197.528	3104.9	½	218.341	3793.7
⅜	177.107	2496.1	63.	197.920	3117.2	⅝	218.733	3807.3
½	177.500	2507.2	⅛	198.313	3129.6	¾	219.126	3821.0
⅝	177.893	2518.3	¼	198.706	3142.0	⅞	219.519	3834.7

Circumferences and Areas of Circles—Continued

Diam.	Circum.	Area	Diam.	Circum.	Area	Diam.	Circum.	Area
70.	219.911	3848.5	**76⅝**	240.725	4611.4	**83¼**	261.538	5443.3
⅛	220.304	3862.2	¾	241.117	4626.4	⅜	261.930	5459.6
¼	220.697	3876.0	⅞	241.510	4641.5	½	262.323	5476.0
⅜	221.090	3889.8	**77.**	241.903	4656.6	⅝	262.716	5492.4
½	221.482	3903.6	⅛	242.295	4671.8	¾	263.108	5508.8
⅝	221.875	3917.5	¼	242.688	4686.9	⅞	263.501	5525.3
¾	222.268	3931.4	⅜	243.081	4702.1	**84.**	263.894	5541.8
⅞	222.660	3945.3	½	243.473	4717.3	⅛	264.286	5558 3
71.	223.053	3959.2	⅝	243.866	4732.5	¼	264.679	5574.8
⅛	223.446	3973.1	¾	244.259	4747.8	⅜	265.072	5591.4
¼	223.838	3987.1	⅞	244.652	4763.1	½	265.465	5607 9
⅜	224.231	4001.1	**78.**	245.044	4778.4	⅝	265.857	5624.5
½	224.624	4015.2	⅛	245.437	4793.7	¾	266.250	5641.2
⅝	225.017	4029.2	¼	245.830	4809.0	⅞	266.643	5657.8
¾	225.409	4043.3	⅜	246.222	4824.4	**85.**	267.035	5674.5
⅞	225.802	4057.4	½	246.615	4839.8	⅛	267.428	5691.2
72.	226.195	4071.5	⅝	247.008	4855.2	¼	267.821	5707.9
⅛	226.587	4085.7	¾	247.400	4870.7	⅜	268.213	5724.7
¼	226.980	4099.8	⅞	247.793	4886.2	½	268.606	5741.5
⅜	227.373	4114.0	**79.**	248.186	4901.7	⅝	268.999	5758.3
½	227.765	4128.2	⅛	248.579	4917.2	¾	269.392	5775.1
⅝	228.158	4142.5	¼	248.971	4932.7	⅞	269.784	5791.9
¾	228.551	4156.8	⅜	249.364	4948.3	**86.**	270.177	5808.8
⅞	228.944	4171.1	½	249.757	4963.9	⅛	270.570	5825.7
73.	229.336	4185.4	⅝	250.149	4979.5	¼	270.962	5842.6
⅛	229.729	4199.7	¾	250.542	4995.2	⅜	271.355	5859.6
¼	230.122	4214.1	⅞	250.935	5010 9	½	271.748	5876.5
⅜	230.514	4228.5	**80.**	251.327	5026.5	⅝	272.140	5893.5
½	230.907	4242.9	⅛	251.720	5042 3	¾	272.533	5910.6
⅝	231.300	4257.4	¼	252.113	5058.0	⅞	272 926	5927.6
¾	231.692	4271.8	⅜	252.506	5073.8	**87.**	273.319	5944.7
⅞	232.085	4286.3	½	252.898	5089.6	⅛	273.711	5961.8
74.	232.478	4300.8	⅝	253.291	5105.4	¼	274.104	5978.9
⅛	232.871	4315.4	¾	253.684	5121.2	⅜	274.497	5996.0
¼	233.263	4329.9	⅞	254.076	5137.1	½	274.889	6013.2
⅜	233.656	4344.5	**81.**	254.469	5153.0	⅝	275.282	6030.4
½	234.049	4359.2	⅛	254.862	5168.9	¾	275.675	6047.6
⅝	234.441	4373.8	¼	255.254	5184.9	⅞	276.067	6064.9
¾	234.834	4388.5	⅜	255.647	5200.8	**88.**	276.460	6082.1
⅞	235.227	4403.1	½	256.040	5216.8	⅛	276.853	6099.4
75.	235.619	4417.9	⅝	256.433	5232.8	¼	277.246	6116.7
⅛	236.012	4432.6	¾	256.825	5248.9	⅜	277.638	6134.1
¼	236.405	4447.4	⅞	257 218	5264.9	½	278.031	6151.4
⅜	236.798	4462.2	**82.**	257.611	5281.0	⅝	278.424	6168.8
½	237.190	4477.0	⅛	258.003	5297.1	¾	278.816	6186.2
⅝	237.583	4491.8	¼	258.396	5313.3	⅞	279.209	6203.7
¾	237.976	4506.7	⅜	258.789	5329.4	**89.**	279.602	6221.1
⅞	238.368	4521.5	½	259.181	5345.6	⅛	279.994	6238.6
76.	238.761	4536.5	⅝	259.574	5361.8	¼	280.387	6256.1
⅛	239.154	4551.4	¾	259.967	5378.1	⅜	280.780	6273.7
¼	239.546	4566.4	⅞	260.359	5394.3	½	281.173	6291.2
⅜	239.939	4581.3	**83.**	260.752	5410.6	⅝	281.565	6308.8
½	240.332	4596.3	⅛	261.145	5426.9	¾	281.958	6326.4

Circumferences and Areas of Circles—Concluded

Diam.	Circum.	Area	Diam.	Circum.	Area	Diam.	Circum.	Area
89⅞	282.351	6344.1	93⅜	293.346	6847.8	96⅞	304.342	7370.8
90.	282.743	6361.7	½	293.739	6866.1	97.	304.734	7389.8
⅛	283.136	6379.4	⅝	294.132	6884.5	⅛	305.127	7408.9
¼	283.529	6397.1	¾	294.524	6902.9	¼	305.520	7428.0
⅜	283.921	6414.9	⅞	294.917	6921.3	⅜	305.913	7447.1
½	284.314	6432.6	94.	295.310	6939.8	½	306.305	7466.2
⅝	284.707	6450.4	⅛	295.702	6958.2	⅝	306.698	7485.3
¾	285.100	6468.2	¼	296.095	6976.7	¾	307.091	7504.5
⅞	285.492	6486.0	⅜	296.488	6995.3	⅞	307.483	7523.7
91.	285.885	6503.9	½	296.881	7013.8	98.	307.876	7543.0
⅛	286.278	6521.8	⅝	297.273	7032.4	⅛	308.269	7562.2
¼	286.670	6539.7	¾	297.666	7051.0	¼	308.661	7581.5
⅜	287.063	6557.6	⅞	298.059	7069.6	⅜	309.054	7600.8
½	287.456	6575.5	95.	298.451	7088.2	½	309.447	7620.1
⅝	287.848	6593.5	⅛	298.844	7106.9	⅝	309.840	7639.5
¾	288.241	6611.5	¼	299.237	7125.6	¾	310.232	7658.9
⅞	288.634	6629.6	⅜	299.629	7144.3	⅞	310.625	7678.3
92.	289.027	6647.6	½	300.022	7163.0	99.	311.018	7697.7
⅛	289.419	6665.7	⅝	300.415	7181.8	⅛	311.410	7717.1
¼	289 812	6683.8	¾	300.807	7200.6	¼	311.803	7736.6
⅜	290.205	6701.9	⅞	301.200	7219.4	⅜	312.196	7756.1
½	290.597	6720.1	96.	301.593	7238.2	½	312.588	7775.6
⅝	290.990	6738.2	⅛	301.986	7257.1	⅝	312.981	7795.2
¾	291.383	6756.4	¼	302 378	7276.0	¾	313.374	7814.8
⅞	291.775	6774.7	⅜	302.771	7294.9	⅞	313.767	7834.4
93.	292.168	6792.9	½	303.164	7313.8	100.	314.159	7854.0
⅛	292.561	6811.2	⅝	303.556	7332.8			
¼	292.954	6829.5	¾	303.949	7351.8			

Squares, Cubes, Square Roots, Cube Roots, Logarithms, Reciprocals, Circumferences and Circular Areas of Nos. from 1 to 1000

No.	Square	Cube	Square Root	Cube Root	Log.	1000 x Recip.	No. = Dia. Circum.	No. = Dia. Area
1	1	1	1.0000	1.0000	0.00000	1000.000	3.142	0.7854
2	4	8	1.4142	1.2599	0.30103	500.000	6.283	3.1416
3	9	27	1.7321	1.4422	0.47712	333.333	9.425	7.0686
4	16	64	2.0000	1.5874	0.60206	250.000	12.566	12.5664
5	25	125	2.2361	1.7100	0.69897	200.000	15.708	19.6350
6	36	216	2.4495	1.8171	0.77815	166.667	18.850	28.2743
7	49	343	2.6458	1.9129	0.84510	142.857	21.991	38.4845
8	64	512	2.8284	2.0000	0.90308	125.000	25.133	50.2655
9	81	729	3.0000	2.0801	0.95424	111.111	28.274	63.6173
10	100	1000	3.1623	2.1544	1.00000	100.000	31.416	78.5398
11	121	1331	3.3166	2.2240	1.04139	90.9091	34.558	95.0332
12	144	1728	3.4641	2.2894	1.07918	83.3333	37.699	113.097
13	169	2197	3.6056	2.3513	1.11394	76.9231	40.841	132.732
14	196	2744	3.7417	2.4101	1.14613	71.4286	43.982	153.938
15	225	3375	3.8730	2.4662	1.17609	66.6667	47.124	176.715
16	256	4096	4.0000	2.5198	1.20412	62.5000	50.265	201.062
17	289	4913	4.1231	2.5713	1.23045	58.8235	53.407	226.980
18	324	5832	4.2426	2.6207	1.25527	55.5556	56.549	254.469
19	361	6859	4.3589	2.6684	1.27875	52.6316	59.690	283.529
20	400	8000	4.4721	2.7144	1.30103	50.0000	62.832	314.159
21	441	9261	4.5826	2.7589	1.32222	47.6190	65.973	346.361
22	484	10648	4.6904	2.8020	1.34242	45.4545	69.115	380.133
23	529	12167	4.7958	2.8439	1.36173	43.4783	72.257	415.476
24	576	13824	4.8990	2.8845	1.38021	41.6667	75.398	452.389
25	625	15625	5.0000	2.9240	1.89794	40.0000	78.540	490.874
26	676	17576	5.0990	2.9625	1.41497	38.4615	81.681	530.929
27	729	19683	5.1962	3.0000	1.43136	37.0370	84.823	572.555
28	784	21952	5.2915	3.0366	1.44716	35.7143	87.965	615.752
29	841	24389	5.3852	3.0723	1.46240	34.4828	91.106	660.520
30	900	27000	5.4772	3.1072	1.47712	33.3333	94.248	706.858
31	961	29791	5.5678	3.1414	1.49136	32.2581	97.389	754.768
32	1024	32768	5.6569	3.1748	1.50515	31.2500	100.531	804.248
33	1089	35937	5.7446	3.2075	1.51851	30.3030	103.673	855.299
34	1156	39304	5.8310	3.2396	1.53148	29.4118	106.814	907.920
35	1225	42875	5.9161	3.2711	1.54407	28.5714	109.956	962.113
36	1296	46656	6.0000	3.3019	1.55630	27.7778	113.097	1017.88
37	1369	50653	6.0828	3.3322	1.56820	27.0270	116.239	1075.21
38	1444	54872	6.1644	3.3620	1.57978	26.3158	119.381	1134.11
39	1521	59319	6.2450	3.3912	1.59106	25.6410	122.522	1194.59
40	1600	64000	6.3246	3.4200	1.60206	25.0000	125.66	1256.64
41	1681	68921	6.4031	3.4482	1.61278	24.3902	128.81	1320.25
42	1764	74088	6.4807	3.4760	1.62325	23.8095	131.95	1385.44
43	1849	79507	6.5574	3.5034	1.63347	23.2558	135.09	1452.20
44	1936	85184	6.6332	3.5303	1.64345	22.7273	138.23	1520.53
45	2025	91125	6.7082	3.5569	1.65321	22.2222	141.37	1590.43
46	2116	97336	6.7823	3.5830	1.66276	21.7391	144.51	1661.90
47	2209	103823	6.8557	3.6088	1.67210	21.2766	147.65	1734.94
48	2304	110592	6.9282	3.6342	1.68124	20.8333	150.80	1809.56
49	2401	117649	7.0000	3.6593	1.69020	20.4082	153.94	1885.74

Squares, Cubes, Square Roots, Cube Roots, Logarithms, Reciprocals, Circumferences and Circular Areas of Nos. from 1 to 1000

No.	Square	Cube	Square Root	Cube Root	Log.	1000 x Recip.	No. = Dia.	
							Circum.	Area
50	2500	125000	7.0711	3.6840	1.69897	20.0000	157.08	1963.50
51	2601	132651	7.1414	3.7084	1.70757	19.6078	160.22	2042.82
52	2704	140608	7.2111	3.7325	1.71600	19.2308	163.36	2123.72
53	2809	148877	7.2801	3.7563	1.72428	18.8679	166.50	2206.18
54	2916	157464	7.3485	3.7798	1.73239	18.5185	169.65	2290.22
55	3025	166375	7.4162	3.8030	1.74036	18.1818	172.79	2375.83
56	3136	175616	7.4833	3.8259	1.74819	17.8571	175.93	2463.01
57	3249	185193	7.5498	3.8485	1.75587	17.5439	179.07	2551.76
58	3364	195112	7.6158	3.8709	1.76343	17.2414	182.21	2642.08
59	3481	205379	7.6811	3.8930	1.77085	16.9492	185.35	2733.97
60	3600	216000	7.7460	3.9149	1.77815	16.6667	188.50	2827.43
61	3721	226981	7.8102	3.9365	1.78533	16.3934	191.64	2922.47
62	3844	238328	7.8740	3.9579	1.79239	16.1290	194.78	3019.07
63	3969	250047	7.9373	3.9791	1.79934	15.8730	197.92	3117.25
64	4096	262144	8.0000	4.0000	1.80618	15.6250	201.06	3216.99
65	4225	274625	8.0623	4.0207	1.81291	15.3846	204.20	3318.31
66	4356	287496	8.1240	4.0412	1.81954	15.1515	207.35	3421.19
67	4489	300763	8.1854	4.0615	1.82607	14.9254	210.49	3525.65
68	4624	314432	8.2462	4.0817	1.83251	14.7059	213.63	3631.68
69	4761	328509	8.3066	4.1016	1.83885	14.4928	216.77	3739.28
70	4900	343000	8.3666	4.1213	1.84510	14.2857	219.91	3848.45
71	5041	357911	8.4261	4.1408	1.85126	14.0845	223.05	3959.19
72	5184	373248	8.4853	4.1602	1.85733	13.8889	226.19	4071.50
73	5329	389017	8.5440	4.1793	1.86332	13.6986	229.34	4185.39
74	5476	405224	8.6023	4.1983	1.86923	13.5135	232.48	4300.84
75	5625	421875	8.6603	4.2172	1 87506	13.3333	235.62	4417.86
76	5776	438976	8.7178	4.2358	1.88081	13.1579	238.76	4536.46
77	5929	456533	8.7750	4.2543	1.88649	12.9870	241.90	4656.63
78	6084	474552	8.8318	4.2727	1.89209	12.8205	245.04	4778.36
79	6241	493039	8.8882	4.2908	1.89763	12.6582	248.19	4901.67
80	6400	512000	8.9443	4.3089	1.90309	12.5000	251.33	5026.55
81	6561	531441	9.0000	4.3267	1.90849	12.3457	254.47	5153.00
82	6724	551368	9.0554	4.3445	1.91381	12.1951	257.61	5281.02
83	6889	571787	9.1104	4.3621	1.91908	12.0482	260.75	5410.61
84	7056	592704	9.1652	4.3795	1.92428	11.9048	263.89	5541.77
85	7225	614125	9.2195	4.3968	1.92942	11.7647	267.04	5674.50
86	7396	636056	9.2736	4.4140	1.93450	11.6279	270.18	5808.80
87	7569	658503	9.3274	4.4310	1.93952	11.4943	273.32	5944.68
88	7744	681472	9.3808	4.4480	1.94448	11.3636	276.46	6082.12
89	7921	704969	9.4340	4.4647	1.94939	11.2360	279.60	6221.14
90	8100	729000	9.4868	4.4814	1.95424	11.1111	282.74	6361.73
91	8281	753571	9.5394	4.4979	1.95904	10.9890	285.88	6503.88
92	8464	778688	9.5917	4.5144	1.96379	10.8696	289.03	6647.61
93	8649	804357	9.6437	4.5307	1.96848	10.7527	292.17	6792.91
94	8836	830584	9.6954	4.5468	1.97313	10.6383	295.31	6939.78
95	9025	857375	9.7468	4.5629	1.97772	10.5263	298.45	7088.22
96	9216	884736	9.7980	4.5789	1.98227	10.4167	301.59	7238.23
97	9409	912673	9.8489	4.5947	1.98677	10.3093	304.73	7389.81
98	9604	941192	9.8995	4.6104	1.99123	10.2041	307.88	7542.96
99	9801	970299	9.9499	4.6261	1.99564	10.1010	311.02	7697.69

Squares, Cubes, Square Roots, Cube Roots, Logarithms, Reciprocals, Circumferences and Circular Areas of Nos. from 1 to 1000

No.	Square	Cube	Square Root	Cube Root	Log.	1000 x Recip.	No. = Dia. Circum.	No. = Dia. Area
100	10000	1000000	10.0000	4.6416	2.00000	10.0000	314.16	7853.98
101	10201	1030301	10.0499	4.6570	2.00432	9.90099	317.30	8011.85
102	10404	1061208	10.0995	4.6723	2.00860	9.80392	320.44	8171.28
103	10609	1092727	10.1489	4.6875	2.01284	9.70874	323.58	8332.29
104	10816	1124864	10.1980	4.7027	2.01703	9.61538	326.73	8494.87
105	11025	1157625	10.2470	4.7177	2.02119	9.52381	329.87	8659.01
106	11236	1191016	10.2956	4.7326	2.02531	9.43396	333.01	8824.73
107	11449	1225043	10.3441	4.7475	2.02938	9.34579	336.15	8992.02
108	11664	1259712	10.3923	4.7622	2.03342	9.25926	339.29	9160.88
109	11881	1295029	10.4403	4.7769	2.03743	9.17431	342.43	9331.32
110	12100	1331000	10.4881	4.7914	2.04139	9.09091	345.58	9503.32
111	12321	1367631	10.5357	4.8059	2.04532	9.00901	348.72	9676.89
112	12544	1404928	10.5830	4.8203	2.04922	8.92857	351.86	9852.03
113	12769	1442897	10.6301	4.8346	2.05308	8.84956	355.00	10028.7
114	12996	1481544	10.6771	4.8488	2.05690	8.77193	358.14	10207.0
115	13225	1520875	10.7238	4.8629	2.06070	8.69565	361.28	10386.9
116	13456	1560896	10.7703	4.8770	2.06446	8.62069	364.42	10568.3
117	13689	1601613	10.8167	4.8910	2.06819	8.54701	367.57	10751.3
118	13924	1643032	10.8628	4.9049	2.07188	8.47458	370.71	10935.9
119	14161	1685159	10.9087	4.9187	2.07555	8.40336	373.85	11122.0
120	14400	1728000	10.9545	4.9324	2.07918	8.33333	376.99	11309.7
121	14641	1771561	11.0000	4.9461	2.08279	8.26446	380.13	11499.0
122	14884	1815848	11.0454	4.9597	2.08636	8.19672	383.27	11689.9
123	15129	1860867	11.0905	4.9732	2.08991	8.13008	386.42	11882.8
124	15376	1906624	11.1355	4.9866	2.09342	8.06452	389.56	12076.3
125	15625	1953125	11.1803	5.0000	2.09691	8.00000	392.70	12271.8
126	15876	2000376	11.2250	5.0133	2.10037	7.93651	395.84	12469.0
127	16129	2048383	11.2694	5.0265	2.10380	7.87402	398.98	12667.7
128	16384	2097152	11.3137	5.0397	2.10721	7.81250	402.12	12868.0
129	16641	2146689	11.3578	5.0528	2.11059	7.75194	405.27	13069.8
130	16900	2197000	11.4018	5.0658	2.11394	7.69231	408.41	13273.2
131	17161	2248091	11.4455	5.0788	2.11727	7.63359	411.55	13478.2
132	17424	2299968	11.4891	5.0916	2.12057	7.57576	414.69	13684.8
133	17689	2352637	11.5326	5.1045	2.12385	7.51880	417.83	13892.9
134	17956	2406104	11.5758	5.1172	2.12710	7.46269	420.97	14102.6
135	18225	2460375	11.6190	5.1299	2.13033	7.40741	424.12	14313.9
136	18496	2515456	11.6619	5.1426	2.13354	7.35294	427.26	14526.7
137	18769	2571353	11.7047	5.1551	2.13672	7.29927	430.40	14741.1
138	.19044	2628072	11.7473	5.1676	2.13988	7.24638	433.54	14957.1
139	19321	2685619	11.7898	5.1801	2.14301	7.19424	436.68	15174.7
140	19600	2744000	11.8322	5.1925	2.14613	7.14286	439.82	15393.8
141	19881	2803221	11.8743	5.2048	2.14922	7.09220	442.96	15614.5
142	20164	2863288	11.9164	5.2171	2.15229	7.04225	446.11	15836.8
143	20449	2924207	11.9583	5.2293	2.15534	6.99301	449.25	16060.6
144	20736	2985984	12.0000	5.2415	2.15836	6.94444	452.39	16286.0
145	21025	3048625	12.0416	5.2536	2.16137	6.89655	455.53	16513.0
146	21316	3112136	12.0830	5.2656	2.16435	6.84932	458.67	16741.5
147	21609	3176523	12.1244	5.2776	2.16732	6.80272	461.81	16971.7
148	21904	3241792	12.1655	5.2896	2.17026	6.75676	464.96	17203.4
149	22201	3307949	12.2066	5.3015	2.17319	6.71141	468.10	17436.6

Squares, Cubes, Square Roots, Cube Roots, Logarithms, Reciprocals, Circumferences and Circular Areas of Nos. from 1 to 1000

No.	Square	Cube	Square Root	Cube Root	Log.	1000 x Recip.	No. = Dia.	
							Circum.	Area
150	22500	3375000	12.2474	5.3133	2.17609	6.66667	471.24	17671.5
151	22801	3442951	12.2882	5.3251	2.17898	6.62252	474.38	17907.9
152	23104	3511808	12.3288	5.3368	2.18184	6.57895	477.52	18145.8
153	23409	3581577	12.3693	5.3485	2.18469	6.53595	480.66	18385.4
154	23716	3652264	12.4097	5.3601	2.18752	6.49351	483.81	18626.5
155	24025	3723875	12.4499	5.3717	2.19033	6.45161	486.95	18869.2
156	24336	3796416	12.4900	5.3832	2.19312	6.41026	490.09	19113.4
157	24649	3869893	12.5300	5.3947	2.19590	6.36943	493.23	19359.3
158	24964	3944312	12.5698	5.4061	2.19866	6.32911	496.37	19606.7
159	25281	4019679	12.6095	5.4175	2.20140	6.28931	499.51	19855.7
160	25600	4096000	12.6491	5.4288	2.20412	6.25000	502.65	20106.2
161	25921	4173281	12.6886	5.4401	2.20683	6.21118	505.80	20358.3
162	26244	4251528	12.7279	5.4514	2.20952	6.17284	508.94	20612.0
163	26569	4330747	12.7671	5.4626	2.21219	6.13497	512.08	20867.2
164	26896	4410944	12.8062	5.4737	2.21484	6.09756	515.22	21124.1
165	27225	4492125	12.8452	5.4848	2.21748	6.06061	518.36	21382.5
166	27556	4574296	12.8841	5.4959	2.22011	6.02410	521.50	21642.4
167	27889	4657463	12.9228	5.5069	2.22272	5.98802	524.65	21904.0
168	28224	4741632	12.9615	5.5178	2.22531	5.95238	527.79	22167.1
169	28561	4826809	13.0000	5.5288	2.22789	5.91716	530.93	22431.8
170	28900	4913000	13.0384	5.5397	2.23045	5.88235	534.07	22698.0
171	29241	5000211	13.0767	5.5505	2.23300	5.84795	537.21	22965.8
172	29584	5088448	13.1149	5.5613	2.23553	5.81395	540.35	23235.2
173	29929	5177717	13.1529	5.5721	2.23805	5.78035	543.50	23506.2
174	30276	5268024	13.1909	5.5828	2.24055	5.74713	546.64	23778.7
175	30625	5359375	13.2288	5.5934	2.24304	5.71429	549.78	24052.8
176	30976	5451776	13.2665	5.6041	2.24551	5.68182	552.92	24328.5
177	31329	5545233	13.3041	5.6147	2.24797	5.64972	556.06	24605.7
178	31684	5639752	13.3417	5.6252	2.25042	5.61798	559.20	24884.6
179	32041	5735339	13.3791	5.6357	2.25285	5.58659	562.35	25164.9
180	32400	5832000	13.4164	5.6462	2.25527	5.55556	565.49	25446.9
181	32761	5929741	13.4536	5.6567	2.25768	5.52486	568.63	25730.4
182	33124	6028568	13.4907	5.6671	2.26007	5.49451	571.77	26015.5
183	33489	6128487	13.5277	5.6774	2.26245	5.46448	574.91	26302.2
184	33856	6229504	13.5647	5.6877	2.26482	5.43478	578.05	26590.4
185	34225	6331625	13.6015	5.6980	2.26717	5.40541	581.19	26880.3
186	34596	6434856	13.6382	5.7083	2.26951	5.37634	584.34	27171.6
187	34969	6539203	13.6748	5.7185	2.27184	5.34759	587.48	27464.6
188	35344	6644672	13.7113	5.7287	2.27416	5.31915	590.62	27759.1
189	35721	6751269	13.7477	5.7388	2.27646	5.29101	593.76	28055.2
190	36100	6859000	13.7840	5.7489	2.27875	5.26316	596.90	28352.9
191	36481	6967871	13.8203	5.7590	2.28103	5.23560	600.04	28652.1
192	36864	7077888	13.8564	5.7690	2.28330	5.20833	603.19	28952.9
193	37249	7189057	13.8924	5.7790	2.28556	5.18135	606.33	29255.3
194	37636	7301384	13.9284	5.7890	2.28780	5.15464	609.47	29559.2
195	38025	7414875	13.9642	5.7989	2.29003	5.12821	612.61	29864.8
196	38416	7529536	14.0000	5.8088	2.29226	5.10204	615.75	30171.9
197	38809	7645373	14.0357	5.8186	2.29447	5.07614	618.89	30480.5
198	39204	7762392	14.0712	5.8285	2.29667	5.05051	622.04	30790.7
199	39601	7880599	14.1067	5.8383	2.29885	5.02513	625.18	31102.6

Squares, Cubes, Square Roots, Cube Roots, Logarithms, Reciprocals, Circumferences and Circular Areas of Nos. from 1 to 1000

No.	Square	Cube	Square Root	Cube Root	Log.	1000 x Recip.	No. = Dia. Circum.	No. = Dia. Area
200	40000	8000000	14.1421	5.8480	2.30103	5.00000	628.32	31415.9
201	40401	8120601	14.1774	5.8578	2.30320	4.97512	631.46	31730.9
202	40804	8242408	14.2127	5.8675	2.30535	4.95050	634.60	32047.4
203	41209	8365427	14.2478	5.8771	2.30750	4.92611	637.74	32365.5
204	41616	8489664	14.2829	5.8868	2.30963	4.90196	640.89	32685.1
205	42025	8615125	14.3178	5.8964	2.31175	4.87805	644.03	33006.4
206	42436	8741816	14.3527	5.9059	2.31387	4.85437	647.17	33329.2
207	42849	8869743	14.3875	5.9155	2.31597	4.83092	650.31	33653.5
208	43264	8998912	14.4222	5.9250	2.31806	4.80769	653.45	33979.5
209	43681	9129329	14.4568	5.9345	2.32015	4.78469	656.59	34307.0
210	44100	9261000	14.4914	5.9439	2.32222	4.76190	659.73	34636.1
211	44521	9393931	14.5258	5.9533	2.32428	4.73934	662.88	34966.7
212	44944	9528128	14.5602	5.9627	2.32634	4.71698	666.02	35298.9
213	45369	9663597	14.5945	5.9721	2.32838	4.69484	669.16	35632.7
214	45796	9800344	14.6287	5.9814	2.33041	4.67290	672.30	35968.1
215	46225	9938375	14.6629	5.9907	2.33244	4.65116	675.44	36305.0
216	46656	10077696	14.6969	6.0000	2.33445	4.62963	678.58	36643.5
217	47089	10218313	14.7309	6.0092	2.33646	4.60829	681.73	36983.6
218	47524	10360232	14.7648	6.0185	2.33846	4.58716	684.87	37325.3
219	47961	10503459	14.7986	6.0277	2.34044	4.56621	688.01	37668.5
220	48400	10648000	14.8324	6.0368	2.34242	4.54545	691.15	38013.3
221	48841	10793861	14.8661	6.0459	2.34439	4.52489	694.29	38359.6
222	49284	10941048	14.8997	6.0550	2.34635	4.50450	697.43	38707.6
223	49729	11089567	14.9332	6.0641	2.34830	4.48431	700.58	39057.1
224	50176	11239424	14.9666	6.0732	2.35025	4.46429	703.72	39408.1
225	50625	11390625	15.0000	6.0822	2.35218	4.44444	706.86	39760.8
226	51076	11543176	15.0333	6.0912	2.35411	4.42478	710.00	40115.0
227	51529	11697083	15.0665	6.1002	2.35603	4.40529	713.14	40470.8
228	51984	11852352	15.0997	6.1091	2.35793	4.38596	716.28	40828.1
229	52441	12008989	15.1327	6.1180	2.35984	4.36681	719.42	41187.1
230	52900	12167000	15.1658	6.1269	2.36173	4.34783	722.57	41547.6
231	53361	12326391	15.1987	6.1358	2.36361	4.32900	725.71	41909.6
232	53824	12487168	15.2315	6.1446	2.36549	4.31034	728.85	42273.3
233	54289	12649337	15.2643	6.1534	2.36736	4.29185	731.99	42638.5
234	54756	12812904	15.2971	6.1622	2.36922	4.27350	735.13	43005.3
235	55225	12977875	15.3297	6.1710	2.37107	4.25532	738.27	43373.6
236	55696	13144256	15.3623	6.1797	2.37291	4.23729	741.42	43743.5
237	56169	13312053	15.3948	6.1885	2.37475	4.21941	744.56	44115.0
238	56644	13481272	15.4272	6.1972	2.37658	4.20168	747.70	44488.1
239	57121	13651919	15.4596	6.2058	2.37840	4.18410	750.84	44862.7
240	57600	13824000	15.4919	6.2145	2.38021	4.16667	753.98	45238.9
241	58081	13997521	15.5242	6.2231	2.38202	4.14938	757.12	45616.7
242	58564	14172488	15.5563	6.2317	2.38382	4.13223	760.27	45996.1
243	59049	14348907	15.5885	6.2403	2.38561	4.11523	763.41	46377.0
244	59536	14526784	15.6205	6.2488	2.38739	4.09836	766.55	46759.5
245	60025	14706125	15.6525	6.2573	2.38917	4.08163	769.69	47143.5
246	60516	14886936	15.6844	6.2658	2.39094	4.06504	772.83	47529.2
247	61009	15069223	15.7162	6.2743	2.39270	4.04858	775.97	47916.4
248	61504	15252992	15.7480	6.2828	2.39445	4.03226	779.12	48305.1
249	62001	15438249	15.7797	6.2912	2.39620	4.01606	782.26	48695.5

Squares, Cubes, Square Roots, Cube Roots, Logarithms, Reciprocals, Circumferences and Circular Areas of Nos. from 1 to 1000

No.	Square	Cube	Square Root	Cube Root	Log.	1000 x Recip.	No. = Dia. Circum.	No. = Dia. Area
250	62500	15625000	15.8114	6.2996	2.39794	4.00000	785.40	49087.4
251	63001	15813251	15.8430	6.3080	2.39967	3.98406	788.54	49480.9
252	63504	16003008	15.8745	6.3164	2.40140	3.96825	791.68	49875.9
253	64009	16194277	15.9060	6.3247	2.40312	3.95257	794.82	50272.6
254	64516	16387064	15.9374	6.3330	2.40483	3.93701	797.96	50670.7
255	65025	16581375	15.9687	6.3413	2.40654	3.92157	801.81	51070.5
256	65536	16777216	16.0000	6.3496	2.40824	3.90625	804.25	51471.9
257	66049	16974593	16.0312	6.3579	2.40993	3.89105	807.39	51874.8
258	66564	17173512	16.0624	6.3661	2.41162	3.87597	810.53	52279.2
259	67081	17373979	16.0935	6.3743	2.41330	3.86100	813.67	52685.3
260	67600	17576000	16.1245	6.3825	2.41497	3.84615	816.81	53092.9
261	68121	17779581	16.1555	6.3907	2.41664	3.83142	819.96	53502.1
262	68644	17984728	16.1864	6.3988	2.41830	3.81679	823.10	53912.9
263	69169	18191447	16.2173	6.4070	2.41996	3.80228	826.24	54325.2
264	69696	18399744	16.2481	6.4151	2.42160	3.78788	829.38	54739.1
265	70225	18609625	16.2788	6.4232	2.42325	3.77358	832.52	55154.6
266	70756	18821096	16.3095	6.4312	2.42488	3.75940	835.66	55571.6
267	71289	19034163	16 3401	6.4393	2.42651	3.74532	838.81	55990.3
268	71824	19248832	16.3707	6.4473	2.42813	3.73134	841.95	56410.4
269	72361	19465109	16.4012	6.4553	2.42975	3.71747	845.09	56832.2
270	72900	19683000	16.4317	6.4633	2.43136	3.70370	848.23	57255.5
271	73441	19902511	16.4621	6.4713	2.43297	3.69004	851.37	57680.4
272	73984	20123648	16.4924	6.4792	2.43457	3.67647	854.51	58106.9
273	74529	20346417	16.5227	6.4872	2.43616	3.66300	857.66	58534.9
274	75076	20570824	16.5529	6.4951	2.43775	3.64964	860.80	58964.6
275	75625	20796875	16.5831	6.5030	2.43933	3.63636	863.94	59395.7
276	76176	21024576	16.6132	6.5108	2.44091	3.62319	867.08	59828.5
277	76729	21253933	16.6433	6.5187	2.44248	3.61011	870.22	60262.8
278	77284	21484952	16.6733	6.5265	2.44404	3.59712	873.36	60698.7
279	77841	21717639	16.7033	6.5343	2.44560	3.58423	876.50	61136.2
280	78400	21952000	16.7332	6.5421	2.44716	3.57143	879.65	61575.2
281	78961	22188041	16.7631	6.5499	2.44871	3.55872	882.79	62015.8
282	79524	22425768	16.7929	6.5577	2.45025	3.54610	885.93	62458.0
283	80089	22665187	16.8226	6.5654	2.45179	3.53357	889.07	62901.8
284	80656	22906304	16.8523	6.5731	2.45332	3.52113	892.21	63347.1
285	81225	23149125	16.8819	6.5808	2.45484	3.50877	895.35	63794.0
286	81796	23393656	16.9115	6.5885	2.45637	3.49650	898.50	64242.4
287	82369	23639903	16.9411	6.5962	2.45788	3.48432	901.64	64692.5
288	82944	23887872	16.9706	6.6039	2.45939	3.47222	904.78	65144.1
289	83521	24137569	17.0000	6.6115	2.46090	3.46021	907.92	65597.2
290	84100	24389000	17.0294	6.6191	2.46240	3.44828	911.06	66052.0
291	84681	24642171	17.0587	6.6267	2.46389	3.43643	914.20	66508.3
292	85264	24897088	17.0880	6.6343	2.46538	3.42466	917.35	66966.2
293	85849	25153757	17.1172	6.6419	2.46687	3.41297	920.49	67425.6
294	86436	25412184	17.1464	6.6494	2.46835	3.40136	923.63	67886.7
295	87025	25672375	17.1756	6.6569	2.46982	3.38983	926.77	68349.3
296	87616	25934336	17.2047	6.6644	2.47129	3.37838	929.91	68813.5
297	88209	26198073	17.2337	6.6719	2.47276	3.36700	933.05	69279.2
298	88804	26463592	17.2627	6.6794	2.47422	3.35570	936.19	69746.5
299	89401	26730899	17.2916	6.6869	2.47567	3.34448	939.34	70215.4

Squares, Cubes, Square Roots, Cube Roots, Logarithms, Reciprocals, Circumferences and Circular Areas of Nos. from 1 to 1000

No.	Square	Cube	Square Root	Cube Root	Log.	1000 x Recip.	No. = Dia. Circum.	No. = Dia. Area
300	90000	27000000	17.3205	6.6943	2.47712	3.33333	942.48	70685.8
301	90601	27270901	17.3494	6.7018	2.47857	3.32226	945.62	71157.9
302	91204	27543608	17.3781	6.7092	2.48001	3.31126	948.76	71631.5
303	91809	27818127	17.4069	6.7166	2.48144	3.30033	951.90	72106.6
304	92416	28094464	17.4356	6.7240	2.48287	3.28947	955.04	72583.4
305	93025	28372625	17.4642	6.7313	2.48430	3.27869	958.19	73061.7
306	93636	28652616	17.4929	6.7387	2.48572	3.26797	961.33	73541.5
307	94249	28934443	17.5214	6.7460	2.48714	3.25733	964.47	74023.0
308	94864	29218112	17.5499	6.7533	2.48855	3.24675	967.61	74506.0
309	95481	29503629	17.5784	6.7606	2.48996	3.23625	970.75	74990.6
310	96100	29791000	17.6068	6.7679	2.49136	3.22581	973.89	75476.8
311	96721	30080231	17.6352	6.7752	2.49276	3.21543	977.04	75964.5
312	97344	30371328	17.6635	6.7824	2.49415	3.20513	980.18	76453.8
313	97969	30664297	17.6918	6.7897	2.49554	3.19489	983.32	76944.7
314	98596	30959144	17.7200	6.7969	2.49693	3.18471	986.46	77437.1
315	99225	31255875	17.7482	6.8041	2.49831	3.17460	989.60	77931.1
316	99856	31554496	17.7764	6.8113	2.49969	3.16456	992.74	78426.7
317	100489	31855013	17.8045	6.8185	2.50106	3.15457	995.88	78923.9
318	101124	32157432	17.8326	6.8256	2.50243	3.14465	999.03	79422.6
319	101761	32461759	17.8606	6.8328	2.50379	3.13480	1002.2	79922.9
320	102400	32768000	17.8885	6.8399	2.50515	3.12500	1005.3	80424.8
321	103041	33076161	17.9165	6.8470	2.50651	3.11527	1008.5	80928.2
322	103684	33386248	17.9444	6.8541	2.50786	3.10559	1011.6	81433.2
323	104329	33698267	17.9722	6.8612	2.50920	3.09598	1014.7	81939.8
324	104976	34012224	18.0000	6.8683	2.51055	3.08642	1017.9	82448.0
325	105625	34328125	18.0278	6.8753	2.51188	3.07692	1021.0	82957.7
326	106276	34645976	18.0555	6.8824	2.51322	3.06749	1024.2	83469.0
327	106929	34965783	18.0831	6.8894	2.51455	3.05810	1027.3	83981.8
328	107584	35287552	18.1108	6.8964	2.51587	3.04878	1030.4	84496.3
329	108241	35611289	18.1384	6.9034	2.51720	3.03951	1033.6	85012.3
330	108900	35937000	18.1659	6.9104	2.51851	3.03030	1036.7	85529.9
331	109561	36264691	18.1934	6.9174	2.51983	3.02115	1039.9	86049.0
332	110224	36594368	18.2209	6.9244	2.52114	3.01205	1043.0	86569.7
333	110889	36926037	18.2483	6.9313	2.52244	3.00300	1046.2	87092.0
334	111556	37259704	18.2757	6.9382	2.52375	2.99401	1049.3	87615.9
335	112225	37595375	18.3030	6.9451	2.52504	2.98507	1052.4	88141.3
336	112896	37933056	18.3303	6.9521	2.52634	2.97619	1055.6	88668.3
337	113569	38272753	18.3576	6.9589	2.52763	2.96736	1058.7	89196.9
338	114244	38614472	18.3848	6.9658	2.52892	2.95858	1061.9	89727.0
339	114921	38958219	18.4120	6.9727	2.53020	2.94985	1065.0	90258.7
340	115600	39304000	18.4391	6.9795	2.53148	2.94118	1068.1	90792.0
341	116281	39651821	18.4662	6.9864	2.53275	2.93255	1071.3	91326.9
342	116964	40001688	18.4932	6.9932	2.53403	2.92398	1074.4	91863.3
343	117649	40353607	18.5203	7.0000	2.53529	2.91545	1077.6	92401.3
344	118336	40707584	18.5472	7.0068	2.53656	2.90698	1080.7	92940.9
345	119025	41063625	18.5742	7.0136	2.53782	2.89855	1083.8	93482.0
346	119716	41421736	18.6011	7.0203	2.53908	2.89017	1087.0	94024.7
347	120409	41781923	18.6279	7.0271	2.54033	2.88184	1090.1	94569.0
348	121104	42144192	18.6548	7.0338	2.54158	2.87356	1093.3	95114.9
349	121801	42508549	18.6815	7.0406	2.54283	2.86533	1096.4	95662.3

Squares, Cubes, Square Roots, Cube Roots, Logarithms, Reciprocals, Circumferences and Circular Areas of Nos. from 1 to 1000

No.	Square	Cube	Square Root	Cube Root	Log.	1000 x Recip.	No. = Dia. Circum.	No. = Dia. Area
350	122500	42875000	18.7083	7.0473	2.54407	2.85714	1099.6	96211.3
351	123201	43243551	18.7350	7.0540	2.54531	2.84900	1102.7	96761.8
352	123904	43614208	18.7617	7.0607	2.54654	2.84091	1105.8	97314.0
353	124609	43986977	18.7883	7.0674	2.54777	2.83286	1109.0	97867.7
354	125316	44361864	18.8149	7.0740	2.54900	2.82486	1112.1	98423.0
355	126025	44738875	18.8414	7.0807	2.55023	2.81690	1115.3	98979.8
356	126736	45118016	18.8680	7.0873	2.55145	2.80899	1118.4	99538.2
357	127449	45499293	18.8944	7.0940	2.55267	2.80112	1121.5	100098
358	128164	45882712	18.9209	7.1006	2.55388	2.79330	1124.7	100660
359	128881	46268279	18.9473	7.1072	2.55509	2.78552	1127.8	101223
360	129600	46656000	18.9737	7.1138	2.55630	2.77778	1131.0	101788
361	130321	47045881	19.0000	7.1204	2.55751	2.77008	1134.1	102354
362	131044	47437928	19.0263	7.1269	2.55871	2.76243	1137.3	102922
363	131769	47832147	19.0526	7.1335	2.55991	2.75482	1140.4	103491
364	132496	48228544	19.0788	7.1400	2.56110	2.74725	1143.5	104062
365	133225	48627125	19.1050	7.1466	2.56229	2.73973	1146.7	104635
366	133956	49027896	19.1311	7.1531	2.56348	2.73224	1149.8	105209
367	134689	49430863	19.1572	7.1596	2.56467	2.72480	1153.0	105785
368	135424	49836032	19.1833	7.1661	2.56585	2.71739	1156.1	106362
369	136161	50243409	19.2094	7.1726	2.56703	2.71003	1159.2	106941
370	136900	50653000	19.2354	7.1791	2.56820	2.70270	1162.4	107521
371	137641	51064811	19.2614	7.1855	2.56937	2.69542	1165.5	108103
372	138384	51478848	19.2873	7.1920	2.57054	2.68817	1168.7	108687
373	139129	51895117	19.3132	7.1984	2.57171	2.68097	1171.8	109272
374	139876	52313624	19.3391	7.2048	2.57287	2.67380	1175.0	109858
375	140625	52734375	19.3649	7.2112	2.57403	2.66667	1178.1	110447
376	141376	53157376	19.3907	7.2177	2.57519	2.65957	1181.2	111036
377	142129	53582633	19.4165	7.2240	2.57634	2.65252	1184.4	111628
378	142884	54010152	19.4422	7.2304	2.57749	2.64550	1187.5	112221
379	143641	54439939	19.4679	7.2368	2.57864	2.63852	1190.7	112815
380	144400	54872000	19.4936	7.2432	2.57978	2.63158	1193.8	113411
381	145161	55306341	19.5192	7.2495	2.58093	2.62467	1196.9	114009
382	145924	55742968	19.5448	7.2558	2.58206	2.61780	1200.1	114608
383	146689	56181887	19.5704	7.2622	2.58320	2.61097	1203.2	115209
384	147456	56623104	19.5959	7.2685	2.58433	2.60417	1206.4	115812
385	148225	57066625	19.6214	7.2748	2.58546	2.59740	1209.5	116416
386	148996	57512456	19.6469	7.2811	2.58659	2.59067	1212.7	117021
387	149769	57960603	19.6723	7.2874	2.58771	2.58398	1215.8	117628
388	150544	58411072	19.6977	7.2936	2.58883	2.57732	1218.9	118237
389	151321	58863869	19.7231	7.2999	2.58995	2.57069	1222.1	118847
390	152100	59319000	19.7484	7.3061	2.59106	2.56410	1225.2	119459
391	152881	59776471	19.7737	7.3124	2.59218	2.55755	1228.4	120072
392	153664	60236288	19.7990	7.3186	2.59329	2.55102	1231.5	120687
393	154449	60698457	19.8242	7.3248	2.59439	2.54453	1234.6	121304
394	155236	61162984	19.8494	7.3310	2.59550	2.53807	1237.8	121922
395	156025	61629875	19.8746	7.3372	2 59660	2.53165	1240.9	122542
396	156816	62099136	19.8997	7.3434	2.59770	2.52525	1244.1	123163
397	157609	62570773	19.9249	7.3496	2.59879	2.51889	1247.2	123786
398	158404	63044792	19.9499	7.3558	2.59988	2.51256	1250.4	124410
399	159201	63521199	19.9750	7.3619	2.60097	2.50627	1253.5	125036

Squares, Cubes, Square Roots, Cube Roots, Logarithms, Reciprocals, Circumferences and Circular Areas of Nos. from 1 to 1000

No.	Square	Cube	Square Root	Cube Root	Log.	1000 x Recip.	No. = Dia. Circum.	No. = Dia. Area
400	160000	64000000	20.0000	7.3681	2.60206	2.50000	1256.6	125664
401	160801	64481201	20.0250	7.3742	2.60314	2.49377	1259.8	126293
402	161604	64964808	20.0499	7.3803	2.60423	2.48756	1262.9	126923
403	162409	65450827	20.0749	7.3864	2.60531	2.48139	1266.1	127556
404	163216	65939264	20.0998	7.3925	2.60638	2.47525	1269.2	128190
405	164025	66430125	20.1246	7.3986	2.60746	2.46914	1272.3	128825
406	164836	66923416	20.1494	7.4047	2.60853	2.46305	1275.5	129462
407	165649	67419143	20.1742	7.4108	2.60959	2.45700	1278.6	130100
408	166464	67917312	20.1990	7.4169	2.61066	2.45098	1281.8	130741
409	167281	68417929	20.2237	7.4229	2.61172	2.44499	1284.9	131382
410	168100	68921000	20.2485	7.4290	2.61278	2.43902	1288.1	132025
411	168921	69426531	20.2731	7.4350	2.61384	2.43309	1291.2	132670
412	169744	69934528	20.2978	7.4410	2.61490	2.42718	1294.3	133317
413	170569	70444997	20.3224	7.4470	2.61595	2.42131	1297.5	133965
414	171396	70957944	20.3470	7.4530	2.61700	2.41546	1300.6	134614
415	172225	71473375	20.3715	7.4590	2.61805	2.40964	1303.8	135265
416	173056	71991296	20.3961	7.4650	2.61909	2.40385	1306.9	135918
417	173889	72511713	20.4206	7.4710	2.62014	2.39808	1310.0	136572
418	174724	73034632	20.4450	7.4770	2.62118	2.39234	1313.2	137228
419	175561	73560059	20.4695	7.4829	2.62221	2.38664	1316.3	137885
420	176400	74088000	20.4939	7.4889	2.62325	2.38095	1319.5	138544
421	177241	74618461	20.5183	7.4948	2.62428	2.37530	1322.6	139205
422	178084	75151448	20.5426	7.5007	2.62531	2.36967	1325.8	139867
423	178929	75686967	20.5670	7.5067	2.62634	2.36407	1328.9	140531
424	179776	76225024	20.5913	7.5126	2.62737	2.35849	1332.0	141196
425	180625	76765625	20.6155	7.5185	2.62839	2.35294	1335.2	141863
426	181476	77308776	20.6398	7.5244	2.62941	2.34742	1338.3	142531
427	182329	77854483	20.6640	7.5302	2.63043	2.34192	1341.5	143201
428	183184	78402752	20.6882	7.5361	2.63144	2.33645	1344.6	143872
429	184041	78953589	20.7123	7.5420	2.63246	2.33100	1347.7	144545
430	184900	79507000	20.7364	7.5478	2.63347	2.32558	1350.9	145220
431	185761	80062991	20.7605	7.5537	2.63448	2.32019	1354.0	145896
432	186624	80621568	20.7846	7.5595	2.63548	2.31482	1357.2	146574
433	187489	81182737	20.8087	7.5654	2.63649	2.30947	1360.3	147254
434	188356	81746504	20.8327	7.5712	2.63749	2.30415	1363.5	147934
435	189225	82312875	20.8567	7.5770	2.63849	2.29885	1366.6	148617
436	190096	82881856	20.8806	7.5828	2.63949	2.29358	1369.7	149301
437	190969	83453453	20.9045	7.5886	2.64048	2.28833	1372.9	149987
438	191844	84027672	20.9284	7.5944	2.64147	2.28311	1376.0	150674
439	192721	84604519	20.9523	7.6001	2.64246	2.27790	1379.2	151363
440	193600	85184000	20.9762	7.6059	2.64345	2.27273	1382.3	152053
441	194481	85766121	21.0000	7.6117	2.64444	2.26757	1385.4	152745
442	195364	86350888	21.0238	7.6174	2.64542	2.26244	1388.6	153439
443	196249	86938307	21.0476	7.6232	2.64640	2.25734	1391.7	154134
444	197136	87528384	21.0713	7.6289	2.64738	2.25225	1394.9	154830
445	198025	88121125	21.0950	7.6346	2.64836	2.24719	1398.0	155528
446	198916	88716536	21.1187	7.6403	2.64933	2.24215	1401.2	156228
447	199809	89314623	21.1424	7.6460	2.65031	2.23714	1404.3	156930
448	200704	89915392	21.1660	7.6517	2.65128	2.23214	1407.4	157633
449	201601	90518849	21.1896	7.6574	2.65225	2.22717	1410.6	158337

Squares, Cubes, Square Roots, Cube Roots, Logarithms, Reciprocals, Circumferences and Circular Areas of Nos. from 1 to 1000

No.	Square	Cube	Square Root	Cube Root	Log.	1000 x Recip.	No. = Dia.	
							Circum.	Area
450	202500	91125000	21.2132	7.6631	2.65321	2.22222	1413.7	159043
451	203401	91733851	21.2368	7.6688	2.65418	2.21730	1416.9	159751
452	204304	92345408	21.2603	7.6744	2.65514	2.21239	1420.0	160460
453	205209	92959677	21.2838	7.6801	2.65610	2.20751	1423.1	161171
454	206116	93576664	21.3073	7.6857	2.65706	2.20264	1426.3	161883
455	207025	94196375	21.3307	7.6914	2.65801	2.19780	1429.4	162597
456	207936	94818816	21.3542	7.6970	2.65896	2.19298	1432.6	163313
457	208849	95443993	21.3776	7.7026	2.65992	2.18818	1435.7	164030
458	209764	96071912	21.4009	7.7082	2.66087	2.18341	1438.9	164748
459	210681	96702579	21.4243	7.7138	2.66181	2.17865	1442.0	165468
460	211600	97336000	21.4476	7.7194	2.66276	2.17391	1445.1	166190
461	212521	97972181	21.4709	7.7250	2.66370	2.16920	1448.3	166914
462	213444	98611128	21.4942	7.7306	2.66464	2.16450	1451.4	167639
463	214369	99252847	21.5174	7.7362	2.66558	2.15983	1454.6	168365
464	215296	99897344	21.5407	7.7418	2.66652	2.15517	1457.7	169093
465	216225	100544625	21.5639	7.7473	2.66745	2.15054	1460.8	169823
466	217156	101194696	21.5870	7.7529	2.66839	2.14592	1464.0	170554
467	218089	101847563	21.6102	7.7584	2.66932	2.14133	1467.1	171287
468	219024	102503232	21.6333	7.7639	2.67025	2.13675	1470.3	172021
469	219961	103161709	21.6564	7.7695	2.67117	2.13220	1473.4	172757
470	220900	103823000	21.6795	7.7750	2.67210	2.12766	1476.5	173494
471	221841	104487111	21.7025	7.7805	2.67302	2.12314	1479.7	174234
472	222784	105154048	21.7256	7.7860	2.67394	2.11864	1482.8	174974
473	223729	105823817	21.7486	7.7915	2.67486	2.11417	1486.0	175716
474	224676	106496424	21.7715	7.7970	2.67578	2.10971	1489.1	176460
475	225625	107171875	21.7945	7.8025	2.67669	2.10526	1492.3	177205
476	226576	107850176	21.8174	7.8079	2.67761	2.10084	1495.4	177952
477	227529	108531333	21.8403	7.8134	2.67852	2.09644	1498.5	178701
478	228484	109215352	21.8632	7.8188	2.67943	2.09205	1501.7	179451
479	229441	109902239	21.8861	7.8243	2.68034	2.08768	1504.8	180203
480	230400	110592000	21.9089	7.8297	2.68124	2.08333	1508.0	180956
481	231361	111284641	21.9317	7.8352	2.68215	2.07900	1511.1	181711
482	232324	111980168	21.9545	7.8406	2.68305	2.07469	1514.3	182467
483	233289	112678587	21.9773	7.8460	2.68395	2.07039	1517.4	183225
484	234256	113379904	22.0000	7.8514	2.68485	2.06612	1520.5	183984
485	235225	114084125	22.0227	7.8568	2.68574	2.06186	1523.7	184745
486	236196	114791256	22.0454	7.8622	2.68664	2.05761	1526.8	185508
487	237169	115501303	22.0681	7.8676	2.68753	2.05339	1530.0	186272
488	238144	116214272	22.0907	7.8730	2.68842	2.04918	1533.1	187038
489	239121	116930169	22.1133	7.8784	2.68931	2.04499	1536.2	187805
490	240100	117649000	22.1359	7.8837	2.69020	2.04082	1539.4	188574
491	241081	118370771	22.1585	7.8891	2.69108	2.03666	1542.5	189345
492	242064	119095488	22.1811	7.8944	2.69197	2.03252	1545.7	190117
493	243049	119823157	22.2036	7.8998	2 69285	2.02840	1548.8	190890
494	244036	120553784	22.2261	7.9051	2.69373	2.02429	1551.9	191665
495	245025	121287375	22.2486	7.9105	2.69461	2.02020	1555.1	192442
496	246016	122023936	22.2711	7.9158	2.69548	2.01613	1558.2	193221
497	247009	122763473	22.2935	7.9211	2 69636	2.01207	1561.4	194000
498	248004	123505992	22.3159	7.9264	2.69723	2.00803	1564.5	194782
499	249001	124251499	22.3383	7.9317	2.69810	2.00401	1567.7	195565

Squares, Cubes, Square Roots, Cube Roots, Logarithms, Reciprocals, Circumferences and Circular Areas of Nos. from 1 to 1000

No.	Square	Cube	Square Root	Cube Root	Log.	1000 x Recip.	No. = Dia. Circum.	No. = Dia. Area
500	250000	125000000	22.3607	7.9370	2.69897	2.00000	1570.8	196350
501	251001	125751501	22.3830	7.9423	2.69984	1.99601	1573.9	197136
502	252004	126506008	22.4054	7.9476	2.70070	1.99203	1577.1	197923
503	253009	127263527	22.4277	7.9528	2.70157	1.98807	1580.2	198713
504	254016	128024064	22.4499	7.9581	2.70243	1.98413	1583.4	199504
505	255025	128787625	22.4722	7.9634	2.70329	1.98020	1586.5	200296
506	256036	129554216	22.4944	7.9686	2.70415	1.97629	1589.7	201090
507	257049	130323843	22.5167	7.9739	2.70501	1.97239	1592.8	201886
508	258064	131096512	22.5389	7.9791	2.70586	1.96850	1595.9	202683
509	259081	131872229	22.5610	7.9843	2.70672	1.96464	1599.1	203482
510	260100	132651000	22.5832	7.9896	2.70757	1.96078	1602.2	204282
511	261121	133432831	22.6053	7.9948	2.70842	1.95695	1605.4	205084
512	262144	134217728	22.6274	8.0000	2.70927	1.95312	1608.5	205887
513	263169	135005697	22.6495	8.0052	2.71012	1.94932	1611.6	206692
514	264196	135796744	22.6716	8.0104	2.71096	1.94553	1614.8	207499
515	265225	136590875	22.6936	8.0156	2.71181	1.94175	1617.9	208307
516	266256	137388096	22.7156	8.0208	2 71265	1.93798	1621.1	209117
517	267289	138188413	22.7376	8.0260	2.71349	1.93424	1624.2	209928
518	268324	138991832	22.7596	8.0311	2.71433	1.93050	1627.3	210741
519	269361	139798359	22.7816	8.0363	2.71517	1.92678	1630.5	211556
520	270400	140608000	22.8035	8.0415	2.71600	1.92308	1633.6	212372
521	271441	141420761	22.8254	8.0466	2.71684	1.91939	1636.8	213189
522	272484	142236648	22.8473	8.0517	2.71767	1.91571	1639.9	214008
523	273529	143055667	22.8692	8.0569	2.71850	1.91205	1643.1	214829
524	274576	143877824	22.8910	8.0620	2.71933	1.90840	1646.2	215651
525	275625	144703125	22.9129	8.0671	2.72016	1.90476	1649.3	216475
526	276676	145531576	22.9347	8.0723	2.72099	1.90114	1652.5	217301
527	277729	146363183	22.9565	8.0774	2.72181	1.89753	1655.6	218128
528	278784	147197952	22.9783	8.0825	2.72263	1.89394	1658.8	218956
529	279841	148035889	23.0000	8.0876	2.72346	1.89036	1661.9	219787
530	280900	148877000	23.0217	8.0927	2.72428	1.88679	1665.0	220618
531	281961	149721291	23.0434	8.0978	2.72509	1.88324	1668.2	221452
532	283024	150568768	23.0651	8.1028	2.72591	1.87970	1671.3	222287
533	284089	151419437	23.0868	8.1079	2.72673	1.87617	1674.5	223123
534	285156	152273304	23.1084	8.1130	2.72754	1.87266	1677.6	223961
535	286225	153130375	23.1301	8.1180	2.72835	1.86916	1680.8	224801
536	287296	153990656	23.1517	8.1231	2.72916	1.86567	1683.9	225642
537	288369	154854153	23.1733	8.1281	2.72997	1.86220	1687.0	226484
538	289444	155720872	23.1948	8.1332	2.73078	1.85874	1690.2	227329
539	290521	156590819	23.2164	8.1382	2.73159	1.85529	1693.3	228175
540	291600	157464000	23.2379	8.1433	2.73239	1.85185	1696.5	229022
541	292681	158340421	23.2594	8.1483	2.73320	1.84843	1699.6	229871
542	293764	159220088	23.2809	8.1533	2.73400	1.84502	1702.7	230722
543	294849	160103007	23.3024	8.1583	2.73480	1.84162	1705.9	231574
544	295936	160989184	23.3238	8.1633	2.73560	1.83824	1709.0	232428
545	297025	161878625	23.3452	8.1683	2.73640	1.83486	1712.2	233283
546	298116	162771336	23.3666	8.1733	2.73719	1.83150	1715.3	234140
547	299209	163667323	23.3880	8.1783	2.73799	1.82815	1718.5	234998
548	300304	164566592	23.4094	8.1833	2.73878	1.82482	1721.6	235858
549	301401	165469149	23 4307	8.1882	2.73957	1.82149	1724.7	236720

Squares, Cubes, Square Roots, Cube Roots, Logarithms, Reciprocals, Circumferences and Circular Areas of Nos. from 1 to 1000

No.	Square	Cube	Square Root	Cube Root	Log.	1000 x Recip.	No. = Dia.	
							Circum.	Area
550	302500	166375000	23.4521	8.1932	2.74036	1.81818	1727.9	237583
551	303601	167284151	23.4734	8.1982	2.74115	1.81488	1731.0	238448
552	304704	168196608	23.4947	8.2031	2.74194	1.81159	1734.2	239314
553	305809	169112377	23.5160	8.2081	2.74273	1.80832	1737.3	240182
554	306916	170031464	23.5372	8.2130	2.74351	1.80505	1740.4	241051
555	308025	170953875	23.5584	8.2180	2.74429	1.80180	1743.6	241922
556	309136	171879616	23.5797	8.2229	2.74507	1.79856	1746.7	242795
557	310249	172808693	23.6008	8.2278	2.74586	1.79533	1749.9	243669
558	311364	173741112	23.6220	8.2327	2.74663	1.79211	1753.0	244545
559	312481	174676879	23.6432	8.2377	2.74741	1.78891	1756.2	245422
560	313600	175616000	23.6643	8.2426	2.74819	1.78571	1759.3	246301
561	314721	176558481	23.6854	8.2475	2.74896	1.78253	1762.4	247181
562	315844	177504328	23.7065	8.2524	2.74974	1.77936	1765.6	248063
563	316969	178453547	23.7276	8.2573	2.75051	1.77620	1768.7	248947
564	318096	179406144	23.7487	8.2621	2.75128	1.77305	1771.9	249832
565	319225	180362125	23.7697	8.2670	2.75205	1.76991	1775.0	250719
566	320356	181321496	23.7908	8.2719	2.75282	1.76678	1778.1	251607
567	321489	182284263	23.8118	8.2768	2.75358	1.76367	1781.3	252497
568	322624	183250432	23.8328	8.2816	2.75435	1.76056	1784.4	253388
569	323761	184220009	23.8537	8.2865	2.75511	1.75747	1787.6	254281
570	324900	185193000	23.8747	8.2913	2.75587	1.75439	1790.7	255176
571	326041	186169411	23.8956	8.2962	2.75664	1.75131	1793.9	256072
572	327184	187149248	23.9165	8.3010	2.75740	1.74825	1797.0	256970
573	328329	188132517	23.9374	8.3059	2.75815	1.74520	1800.1	257869
574	329476	189119224	23.9583	8.3107	2.75891	1.74216	1803.3	258770
575	330625	190109375	23.9792	8.3155	2.75967	1.73913	1806.4	259672
576	331776	191102976	24.0000	8.3203	2.76042	1.73611	1809.6	260576
577	332929	192100033	24.0208	8.3251	2.76118	1.73310	1812.7	261482
578	334084	193100552	24.0416	8.3300	2.76193	1.73010	1815.8	262389
579	335241	194104539	24.0624	8.3348	2.76268	1.72712	1819.0	263298
580	336400	195112000	24.0832	8.3396	2.76343	1.72414	1822.1	264208
581	337561	196122941	24.1039	8.3443	2.76418	1.72117	1825.3	265120
582	338724	197137368	24.1247	8.3491	2.76492	1.71821	1828.4	266033
583	339889	198155287	24.1454	8.3539	2.76567	1.71527	1831.6	266948
584	341056	199176704	24.1661	8.3587	2.76641	1.71233	1834.7	267865
585	342225	200201625	24.1868	8.3634	2.76716	1.70940	1837.8	268783
586	343396	201230056	24.2074	8.3682	2.76790	1.70649	1841.0	269701
587	344569	202262003	24.2281	8.3730	2.76864	1.70358	1844.1	270624
588	345744	203297472	24.2487	8.3777	2.76938	1.70068	1847.3	271547
589	346921	204336469	24.2693	8.3825	2.77012	1.69779	1850.4	272471
590	348100	205379000	24.2899	8.3872	2.77085	1.69492	1853.5	273397
591	349281	206425071	24.3105	8.3919	2.77159	1.69205	1856.7	274325
592	350464	207474688	24.3311	8.3967	2.77232	1.68919	1859.8	275254
593	351649	208527857	24.3516	8.4014	2.77305	1.68634	1863.0	276184
594	352836	209584584	24.3721	8.4061	2.77379	1.68350	1866.1	277117
595	354025	210644875	24.3926	8.4108	2.77452	1.68067	1869.3	278051
596	355216	211708736	24.4131	8.4155	2.77525	1.67785	1872.4	278986
597	356409	212776173	24.4336	8.4202	2.77597	1.67504	1875.5	279923
598	357604	213847192	24.4540	8.4249	2.77670	1.67224	1878.7	280862
599	358801	214921799	24.4745	8.4296	2.77743	1.66945	1881.8	281802

Squares, Cubes, Square Roots, Cube Roots, Logarithms, Reciprocals, Circumferences and Circular Areas of Nos. from 1 to 1000

No.	Square	Cube	Square Root	Cube Root	Log.	1000 x Recip.	No. = Dia.	
							Circum.	Area
600	360000	216000000	24.4949	8.4343	2.77815	1.66667	1885.0	282743
601	361201	217081801	24.5153	8.4390	2.77887	1.66389	1888.1	283687
602	362404	218167208	24.5357	8.4437	2.77960	1.66113	1891.2	284631
603	363609	219256227	24.5561	8.4484	2.78032	1.65837	1894.4	285578
604	364816	220348864	24.5764	8.4530	2.78104	1.65563	1897.5	286526
605	366025	221445125	24.5967	8.4577	2.78176	1.65289	1900.7	287475
606	367236	222545016	24.6171	8.4623	2.78247	1.65017	1903.8	288426
607	368449	223648543	24.6374	8.4670	2.78319	1.64745	1907.0	289379
608	369664	224755712	24.6577	8.4716	2.78390	1.64474	1910.1	290333
609	370881	225866529	24.6779	8.4763	2.78462	1.64204	1913.2	291289
610	372100	226981000	24.6982	8.4809	2.78533	1.63934	1916.4	292247
611	373321	228099131	24.7184	8.4856	2.78604	1.63666	1919.5	293206
612	374544	229220928	24.7386	8.4902	2.78675	1.63399	1922.7	294166
613	375769	230346397	24.7588	8.4948	2.78746	1.63132	1925.8	295128
614	376996	231475544	24.7790	8.4994	2.78817	1.62866	1928.9	296092
615	378225	232608375	24.7992	8.5040	2.78888	1.62602	1932.1	297057
616	379456	233744896	24.8193	8.5086	2.78958	1.62338	1935.2	298024
617	380689	234885113	24.8395	8.5132	2.79029	1.62075	1938.4	298992
618	381924	236029032	24.8596	8.5178	2.79099	1.61812	1941.5	299962
619	383161	237176659	24.8797	8.5224	2.79169	1.61551	1944.7	300934
620	384400	238328000	24.8998	8.5270	2.79239	1.61290	1947.8	301907
621	385641	239483061	24.9199	8.5316	2.79309	1.61031	1950.9	302882
622	386884	240641848	24.9399	8.5362	2.79379	1.60772	1954.1	303858
623	388129	241804367	24.9600	8.5408	2.79449	1.60514	1957.2	304836
624	389376	242970624	24.9800	8.5453	2.79518	1.60256	1960.4	305815
625	390625	244140625	25.0000	8.5499	2.79588	1.60000	1963.5	306796
626	391876	245314376	25.0200	8.5544	2.79657	1.59744	1966.6	307779
627	393129	246491883	25.0400	8.5590	2.79727	1.59490	1969.8	308763
628	394384	247673152	25.0599	8.5635	2.79796	1.59236	1972.9	309748
629	395641	248858189	25.0799	8.5681	2.79865	1.58983	1976.1	310736
630	396900	250047000	25.0998	8.5726	2.79934	1.58730	1979.2	311725
631	398161	251239591	25.1197	8.5772	2.80003	1.58479	1982.4	312715
632	399424	252435968	25.1396	8.5817	2.80072	1.58228	1985.5	313707
633	400689	253636137	25.1595	8.5862	2.80140	1.57978	1988.6	314700
634	401956	254840104	25.1794	8.5907	2.80209	1.57729	1991.8	315696
635	403225	256047875	25.1992	8.5952	2.80277	1.57480	1994.9	316692
636	404496	257259456	25.2190	8.5997	2.80346	1.57233	1998.1	317690
637	405769	258474853	25.2389	8.6043	2.80414	1.56986	2001.2	318690
638	407044	259694072	25.2587	8.6088	2.80482	1.56740	2004.3	319692
639	408321	260917119	25.2784	8.6132	2.80550	1.56495	2007.5	320695
640	409600	262144000	25.2982	8.6177	2.80618	1.56250	2010.6	321699
641	410881	263374721	25.3180	8.6222	2.80686	1.56006	2013.8	322705
642	412164	264609288	25.3377	8.6267	2.80754	1.55763	2016.9	323713
643	413449	265847707	25.3574	8.6312	2.80821	1.55521	2020.0	324722
644	414736	267089984	25.3772	8.6357	2.80889	1.55280	2023.2	325733
645	416025	268336125	25.3969	8.6401	2.80956	1.55039	2026.3	326745
646	417316	269586136	25.4165	8.6446	2.81023	1.54799	2029.5	327759
647	418609	270840023	25.4362	8.6490	2.81090	1.54560	2032.6	328775
648	419904	272097792	25.4558	8.6535	2.81158	1.54321	2035.8	329792
649	421201	273359449	25.4755	8.6579	2.81224	1.54083	2038.9	330810

Squares, Cubes, Square Roots, Cube Roots, Logarithms, Reciprocals, Circumferences and Circular Areas of Nos. from 1 to 1000

No.	Square	Cube	Square Root	Cube Root	Log.	1000 x Recip.	No. = Dia.	
							Circum.	Area
650	422500	274625000	25.4951	8.6624	2.81291	1.53846	2042.0	331831
651	423801	275894451	25.5147	8.6668	2.81358	1.53610	2045.2	332853
652	425104	277167808	25.5343	8.6713	2.81425	1.53374	2048.3	333876
653	426409	278445077	25.5539	8.6757	2.81491	1.53139	2051.5	334901
654	427716	279726264	25.5734	8.6801	2.81558	1.52905	2054.6	335927
655	429025	281011375	25.5930	8.6845	2.81624	1.52672	2057.7	336955
656	430336	282300416	25.6125	8.6890	2.81690	1.52439	2060.9	337985
657	431649	283593393	25.6320	8.6934	2.81757	1.52207	2064.0	339016
658	432964	284890312	25.6515	8.6978	2.81823	1.51976	2067.2	340049
659	434281	286191179	25.6710	8.7022	2.81889	1.51745	2070.3	341084
660	435600	287496000	25.6905	8.7066	2.81954	1.51515	2073.5	342119
661	436921	288804781	25.7099	8.7110	2.82020	1.51286	2076.6	343157
662	438244	290117528	25.7294	8.7154	2.82086	1.51057	2079.7	344196
663	439569	291434247	25.7488	8.7198	2.82151	1.50830	2082.9	345237
664	440896	292754944	25.7682	8.7241	2.82217	1.50602	2086.0	346279
665	442225	294079625	25.7876	8.7285	2.82282	1.50376	2089.2	347323
666	443556	295408296	25.8070	8.7329	2.82347	1.50150	2092.3	348368
667	444889	296740963	25.8263	8.7373	2.82413	1.49925	2095.4	349415
668	446224	298077632	25.8457	8.7416	2.82478	1.49701	2098.6	350464
669	447561	299418309	25.8650	8.7460	2.82543	1.49477	2101.7	351514
670	448900	300763000	25.8844	8.7503	2.82607	1.49254	2104.9	352565
671	450241	302111711	25.9037	8.7547	2.82672	1.49031	2108.0	353618
672	451584	303464448	25.9230	8.7590	2.82737	1.48810	2111.2	354673
673	452929	304821217	25.9422	8.7634	2.82802	1.48588	2114.3	355730
674	454276	306182024	25.9615	8.7677	2.82866	1.48368	2117.4	356788
675	455625	307546875	25.9808	8.7721	2.82930	1.48148	2120.6	357847
676	456976	308915776	26.0000	8.7764	2.82995	1.47929	2123.7	358908
677	458329	310288733	26.0192	8.7807	2.83059	1.47711	2126.9	359971
678	459684	311665752	26.0384	8.7850	2.83123	1.47493	2130.0	361035
679	461041	313046839	26.0576	8.7893	2.83187	1.47275	2133.1	362101
680	462400	314432000	26.0768	8.7937	2.83251	1.47059	2136.3	363168
681	463761	315821241	26.0960	8.7980	2.83315	1.46843	2139.4	364237
682	465124	317214568	26.1151	8.8023	2.83378	1.46628	2142.6	365308
683	466489	318611987	26.1343	8.8066	2.83442	1.46413	2145.7	366380
684	467856	320013504	26.1534	8.8109	2.83506	1.46199	2148.9	367453
685	469225	321419125	26.1725	8.8152	2.83569	1.45985	2152.0	368528
686	470596	322828856	26.1916	8.8194	2.83632	1.45773	2155.1	369605
687	471969	324242703	26.2107	8.8237	2.83696	1.45560	2158.3	370684
688	473344	325660672	26.2298	8.8280	2.83759	1.45349	2161.4	371764
689	474721	327082769	26.2488	8.8323	2.83822	1.45138	2164.6	372845
690	476100	328509000	26.2679	8.8366	2.83885	1.44928	2167.7	373928
691	477481	329939371	26.2869	8.8408	2.83948	1.44718	2170.8	375013
692	478864	331373888	26.3059	8.8451	2.84011	1.44509	2174.0	376099
693	480249	332812557	26.3249	8.8493	2.84073	1.44300	2177.1	377187
694	481636	334255384	26.3439	8.8536	2.84136	1.44092	2180.3	378276
695	483025	335702375	26.3629	8.8578	2.84198	1.43885	2183.4	379367
696	484416	337153536	26.3818	8.8621	2.84261	1.43678	2186.6	380459
697	485809	338608873	26.4008	8.8663	2.84323	1.43472	2189.7	381554
698	487204	340068392	26.4197	8.8706	2.84386	1.43267	2192.8	382649
699	488601	341532099	26.4386	8.8748	2.84448	1.43062	2196.0	383746

Squares, Cubes, Square Roots, Cube Roots, Logarithms, Reciprocals, Circumferences and Circular Areas of Nos. from 1 to 1000

No.	Square	Cube	Square Root	Cube Root	Log.	1000 x Recip.	No. = Dia.	
							Circum.	Area
700	490000	343000000	26.4575	8.8790	2.84510	1.42857	2199.1	384845
701	491401	344472101	26.4764	8.8833	2.84572	1.42653	2202.3	385945
702	492804	345948408	26.4953	8.8875	2.84634	1.42450	2205.4	387047
703	494209	347428927	26.5141	8.8917	2.84696	1.42248	2208.5	388151
704	495616	348913664	26.5330	8.8959	2.84757	1.42046	2211.7	389256
705	497025	350402625	26.5518	8.9001	2.84819	1.41844	2214.8	390363
706	498436	351895816	26.5707	8.9043	2.84880	1.41643	2218.0	391471
707	499849	353393243	26.5895	8.9085	2.84942	1.41443	2221.1	392580
708	501264	354894912	26.6083	8.9127	2.85003	1.41243	2224.3	393692
709	502681	356400829	26.6271	8.9169	2.85065	1.41044	2227.4	394805
710	504100	357911000	26.6458	8.9211	2.85126	1.40845	2230.5	395919
711	505521	359425431	26.6646	8.9253	2.85187	1.40647	2233.7	397035
712	506944	360944128	26.6833	8.9295	2.85248	1.40449	2236.8	398153
713	508369	362467097	26.7021	8.9337	2.85309	1.40253	2240.0	399272
714	509796	363994344	26.7208	8.9378	2.85370	1.40056	2243.1	400393
715	511225	365525875	26.7395	8.9420	2.85431	1.39860	2246.2	401515
716	512656	367061696	26.7582	8.9462	2.85491	1.39665	2249.4	402639
717	514089	368601813	26.7769	8.9503	2.85552	1.39470	2252.5	403765
718	515524	370146232	26.7955	8.9545	2.85612	1.39276	2255.7	404892
719	516961	371694959	26.8142	8.9587	2.85673	1.39082	2258.8	406020
720	518400	373248000	26.8328	8.9628	2.85733	1.38889	2261.9	407150
721	519841	374805361	26.8514	8.9670	2.85794	1.38696	2265.1	408282
722	521284	376367048	26.8701	8.9711	2.85854	1.38504	2268.2	409416
723	522729	377933067	26.8887	8.9752	2.85914	1.38313	2271.4	410550
724	524176	379503424	26.9072	8.9794	2.85974	1.38122	2274.5	411687
725	525625	381078125	26.9258	8.9835	2.86034	1.37931	2277.7	412825
726	527076	382657176	26.9444	8.9876	2.86094	1.37741	2280.8	413965
727	528529	384240583	26.9629	8.9918	2.86153	1.37552	2283.9	415106
728	529984	385828352	26.9815	8.9959	2.86213	1.37363	2287.1	416248
729	531441	387420489	27.0000	9.0000	2.86273	1.37174	2290.2	417393
730	532900	389017000	27.0185	9.0041	2.86332	1.36986	2293.4	418539
731	534361	390617891	27.0370	9.0082	2.86392	1.36799	2296.5	419686
732	535824	392223168	27.0555	9.0123	2.86451	1.36612	2299.7	420835
733	537289	393832837	27.0740	9.0164	2.86510	1.36426	2302.8	421986
734	538756	395446904	27.0924	9.0205	2.86570	1.36240	2305.9	423138
735	540225	397065375	27.1109	9.0246	2.86629	1.36054	2309.1	424293
736	541696	398688256	27.1293	9.0287	2.86688	1.35870	2312.2	425448
737	543169	400315553	27.1477	9.0328	2.86747	1.35685	2315.4	426604
738	544644	401947272	27.1662	9.0369	2.86806	1.35501	2318.5	427762
739	546121	403583419	27.1846	9.0410	2.86864	1.35318	2321.6	428922
740	547600	405224000	27.2029	9.0450	2.86923	1.35135	2324.8	430084
741	549081	406869021	27.2213	9.0491	2.86982	1.34953	2327.9	431247
742	550564	408518488	27.2397	9.0532	2.87040	1.34771	2331.1	432412
743	552049	410172407	27.2580	9.0572	2.87099	1.34590	2334.2	433578
744	553536	411830784	27.2764	9.0613	2.87157	1.34409	2337.3	434746
745	555025	413493625	27.2947	9.0654	2.87216	1.34228	2340.5	435916
746	556516	415160936	27.3130	9.0694	2.87274	1.34048	2343.6	437087
747	558009	416832723	27.3313	9.0735	2.87332	1.33869	2346.8	438259
748	559504	418508992	27.3496	9.0775	2.87390	1.33690	2349.9	439433
749	561001	420189749	27.3679	9.0816	2.87448	1.33511	2353.1	440609

Squares, Cubes, Square Roots, Cube Roots, Logarithms, Reciprocals, Circumferences and Circular Areas of Nos. from 1 to 1000

No.	Square	Cube	Square Root	Cube Root	Log.	1000 x Recip.	No. = Dia. Circum.	No. = Dia. Area
750	562500	421875000	27.3861	9.0856	2.87506	1.33333	2356.2	441786
751	564001	423564751	27.4044	9.0896	2.87564	1.33156	2359.3	442965
752	565504	425259008	27.4226	9.0937	2.87622	1.32979	2362.5	444146
753	567009	426957777	27.4408	9.0977	2.87680	1.32802	2365.6	445328
754	568516	428661064	27.4591	9.1017	2.87737	1.32626	2368.8	446511
755	570025	430368875	27.4773	9.1057	2.87795	1.32450	2371.9	447697
756	571536	432081216	27.4955	9.1098	2.87852	1.32275	2375.0	448883
757	573049	433798093	27.5136	9.1138	2.87910	1.32100	2378.2	450072
758	574564	435519512	27.5318	9.1178	2.87967	1.31926	2381.3	451262
759	576081	437245479	27.5500	9.1218	2.88024	1.31752	2384.5	452453
760	577600	438976000	27.5681	9.1258	2.88081	1.31579	2387.6	453646
761	579121	440711081	27.5862	9.1298	2.88138	1.31406	2390.8	454841
762	580644	442450728	27.6043	9.1338	2.88196	1.31234	2393.9	456037
763	582169	444194947	27.6225	9.1378	2.88252	1.31062	2397.0	457234
764	583696	445943744	27.6405	9.1418	2.88309	1.30890	2400.2	458434
765	585225	447697125	27.6586	9.1458	2.88366	1.30719	2403.3	459635
766	586756	449455096	27.6767	9.1498	2.88423	1.30548	2406.5	460837
767	588289	451217663	27 6948	9.1537	2.88480	1.30378	2409.6	462042
768	589824	452984832	27.7128	9.1577	2.88536	1.30208	2412.7	463247
769	591361	454756609	27.7308	9.1617	2.88593	1.30039	2415.9	464454
770	592900	456533000	27.7489	9.1657	2.88649	1.29870	2419.0	465663
771	594441	458314011	27.7669	9.1696	2.88705	1.29702	2422.2	466873
772	595984	460099648	27.7849	9.1736	2.88762	1.29534	2425.3	468085
773	597529	461889917	27.8029	9.1775	2.88818	1.29366	2428.5	469298
774	599076	463684824	27.8209	9.1815	2.88874	1.29199	2431.6	470513
775	600625	465484375	27.8388	9.1855	2.88930	1.29032	2434.7	471730
776	602176	467288576	27.8568	9.1894	2.88986	1.28866	2437.9	472948
777	603729	469097433	27.8747	9.1933	2.89042	1.28700	2441.0	474168
778	605284	470910952	27.8927	9.1973	2.89098	1.28535	2444.2	475389
779	606841	472729139	27.9106	9.2012	2.89154	1.28370	2447.3	476612
780	608400	474552000	27.9285	9.2052	2.89209	1.28205	2450.4	477836
781	609961	476379541	27.9464	9.2091	2.89265	1.28041	2453.6	479062
782	611524	478211768	27.9643	9.2130	2.89321	1.27877	2456.7	480290
783	613089	480048687	27.9821	9.2170	2.89376	1.27714	2459.9	481519
784	614656	481890304	28.0000	9.2209	2.89432	1.27551	2463.0	482750
785	616225	483736625	28.0179	9.2248	2.89487	1.27389	2466.2	483982
786	617796	485587656	28.0357	9.2287	2.89542	1.27226	2469.3	485216
787	619369	487443403	28.0535	9.2326	2.89597	1.27065	2472.4	486451
788	620944	489303872	28.0713	9.2365	2.89653	1.26904	2475.6	487688
789	622521	491169069	28.0891	9.2404	2.89708	1.26743	2478.7	488927
790	624100	493039000	28.1069	9.2443	2.89763	1.26582	2481.9	490167
791	625681	494913671	28.1247	9.2482	2.89818	1.26422	2485.0	491409
792	627264	496793088	28.1425	9.2521	2.89873	1.26263	2488.1	492652
793	628849	498677257	28.1603	9.2560	2.89927	1.26103	2491.3	493897
794	630436	500566184	28.1780	9.2599	2.89982	1.25945	2494.4	495143
795	632025	502459875	28.1957	9.2638	2.90037	1.25786	2497.6	496391
796	633616	504358336	28.2135	9.2677	2.90091	1.25628	2500.7	497641
797	635209	506261573	28.2312	9.2716	2.90146	1.25471	2503.8	498892
798	636804	508169592	28.2489	9.2754	2.90200	1.25313	2507.0	500145
799	638401	510082399	28.2666	9.2793	2.90255	1.25156	2510.1	501399

Squares, Cubes, Square Roots, Cube Roots, Logarithms, Reciprocals, Circumferences and Circular Areas of Nos. from 1 to 1000

No.	Square	Cube	Square Root	Cube Root	Log.	1000 x Recip.	No. = Dia.	
							Circum.	Area
800	640000	512000000	28.2843	9.2832	2.90309	1.25000	2513.3	502655
801	641601	513922401	28.3019	9.2870	2.90363	1.24844	2516.4	503912
802	643204	515849608	28.3196	9.2909	2.90417	1.24688	2519.6	505171
803	644809	517781627	28.3373	9.2948	2.90472	1.24533	2522.7	506432
804	646416	519718464	28.3549	9.2986	2.90526	1.24378	2525.8	507694
805	648025	521660125	28.3725	9.3025	2.90580	1.24224	2529.0	508958
806	649636	523606616	28.3901	9.3063	2.90634	1.24069	2532.1	510223
807	651249	525557943	28.4077	9.3102	2.90687	1.23916	2535.3	511490
808	652864	527514112	28.4253	9.3140	2.90741	1.23762	2538.4	512758
809	654481	529475129	28.4429	9.3179	2.90795	1.23609	2541.5	514028
810	656100	531441000	28.4605	9.3217	2.90849	1.23457	2544.7	515300
811	657721	533411731	28.4781	9.3255	2.90902	1.23305	2547.8	516573
812	659344	535387328	28.4956	9.3294	2.90956	1.23153	2551.0	517848
813	660969	537367797	28.5132	9.3332	2.91009	1.23001	2554.1	519124
814	662596	539353144	28.5307	9.3370	2.91062	1.22850	2557.3	520402
815	664225	541343375	28.5482	9.3408	2.91116	1.22699	2560.4	521681
816	665856	543338496	28.5657	9.3447	2.91169	1.22549	2563.5	522962
817	667489	545338513	28.5832	9.3485	2.91222	1.22399	2566.7	524245
818	669124	547343432	28.6007	9.3523	2.91275	1.22249	2569.8	525529
819	670761	549353259	28.6182	9.3561	2.91328	1.22100	2573.0	526814
820	672400	551368000	28.6356	9.3599	2.91381	1.21951	2576.1	528102
821	674041	553387661	28.6531	9.3637	2.91434	1.21803	2579.2	529391
822	675684	555412248	28.6705	9.3675	2.91487	1.21655	2582.4	530681
823	677329	557441767	28.6880	9.3713	2.91540	1.21507	2585.5	531973
824	678976	559476224	28.7054	9.3751	2.91593	1.21359	2588.7	533267
825	680625	561515625	28.7228	9.3789	2.91645	1.21212	2591.8	534562
826	682276	563559976	28.7402	9.3827	2.91698	1.21065	2595.0	535858
827	683929	565609283	28.7576	9.3865	2.91751	1.20919	2598.1	537157
828	685584	567663552	28.7750	9.3902	2.91803	1.20773	2601.2	538456
829	687241	569722789	28.7924	9.3940	2.91855	1.20627	2604.4	539758
830	688900	571787000	28.8097	9.3978	2.91908	1.20482	2607.5	541061
831	690561	573856191	28.8271	9.4016	2.91960	1.20337	2610.7	542365
832	692224	575930368	28.8444	9.4053	2.92012	1.20192	2613.8	543671
833	693889	578009537	28.8617	9.4091	2.92065	1.20048	2616.9	544979
834	695556	580093704	28.8791	9.4129	2.92117	1.19904	2620.1	546288
835	697225	582182875	28.8964	9.4166	2.92169	1.19760	2623.2	547599
836	698896	584277056	28.9137	9.4204	2.92221	1.19617	2626.4	548912
837	700569	586376253	28.9310	9.4241	2.92273	1.19474	2629.5	550226
838	702244	588480472	28.9482	9.4279	2.92324	1.19332	2632.7	551541
839	703921	590589719	28.9655	9.4316	2.92376	1.19189	2635.8	552858
840	705600	592704000	28.9828	9.4354	2.92428	1.19048	2638.9	554177
841	707281	594823321	29.0000	9.4391	2.92480	1.18906	2642.1	555497
842	708964	596947688	29.0172	9.4429	2.92531	1.18765	2645.2	556819
843	710649	599077107	29.0345	9.4466	2.92583	1.18624	2648.4	558142
844	712336	601211584	29.0517	9.4503	2.92634	1.18483	2651.5	559467
845	714025	603351125	29.0689	9.4541	2.92686	1.18343	2654.6	560794
846	715716	605495736	29.0861	9.4578	2.92737	1.18203	2657.8	562122
847	717409	607645423	29.1033	9.4615	2.92788	1.18064	2660.9	563452
848	719104	609800192	29.1204	9.4652	2.92840	1.17925	2664.1	564783
849	720801	611960049	29.1376	9.4690	2.92891	1.17786	2667.2	566116

Squares, Cubes, Square Roots, Cube Roots, Logarithms, Reciprocals, Circumferences and Circular Areas of Nos. from 1 to 1000

No.	Square	Cube	Square Root	Cube Root	Log.	1000 x Recip.	No. = Dia. Circum.	No. = Dia. Area
850	722500	614125000	29.1548	9.4727	2.92942	1.17647	2670.4	567450
851	724201	616295051	29.1719	9.4764	2.92993	1.17509	2673.5	568786
852	725904	618470208	29.1890	9.4801	2.93044	1.17371	2676.6	570124
853	727609	620650477	29.2062	9.4838	2.93095	1.17233	2679.8	571463
854	729316	622835864	29.2233	9.4875	2.93146	1.17096	2682.9	572803
855	731025	625026375	29.2404	9.4912	2.93197	1.16959	2686.1	574146
856	732736	627222016	29.2575	9.4949	2.93247	1.16822	2689.2	575490
857	734449	629422793	29.2746	9.4986	2.93298	1.16686	2692.3	576835
858	736164	631628712	29.2916	9.5023	2.93349	1.16550	2695.5	578182
859	737881	633839779	29.3087	9.5060	2.93399	1.16414	2698.6	579530
860	739600	636056000	29.3258	9.5097	2.93450	1.16279	2701.8	580880
861	741321	638277381	29.3428	9.5134	2.93500	1.16144	2704.9	582232
862	743044	640503928	29.3598	9.5171	2.93551	1.16009	2708.1	583585
863	744769	642735647	29.3769	9.5207	2.93601	1.15875	2711.2	584940
864	746496	644972544	29.3939	9.5244	2.93651	1.15741	2714.3	586297
865	748225	647214625	29.4109	9.5281	2.93702	1.15607	2717.5	587655
866	749956	649461896	29.4279	9.5317	2.93752	1.15473	2720.6	589014
867	751689	651714363	29.4449	9.5354	2.93802	1.15340	2723.8	.590375
868	753424	653972032	29.4618	9.5391	2.93852	1.15207	2726.9	591738
869	755161	656234909	29.4788	9.5427	2.93902	1.15075	2730.0	593102
870	756900	658503000	29.4958	9.5464	2.93952	1.14943	2733.2	594468
871	758641	660776311	29.5127	9.5501	2.94002	1.14811	2736.3	595835
872	760384	663054848	29.5296	9.5537	2.94052	1.14679	2739.5	597204
873	762129	665338617	29.5466	9.5574	2.94101	1.14548	2742.6	598575
874	763876	667627624	29.5635	9.5610	2.94151	1.14416	2745.8	599947
875	765625	669921875	29.5804	9.5647	2.94201	1.14286	2748.9	601320
876	767376	672221376	29.5973	9.5683	2.94250	1.14155	2752.0	602696
877	769129	674526133	29.6142	9.5719	2.94300	1.14025	2755.2	604073
878	770884	676836152	29.6311	9.5756	2.94349	1.13895	2758.3	605451
879	772641	679151439	29.6479	9.5792	2.94399	1.13766	2761.5	606831
880	774400	681472000	29.6648	9.5828	2.94448	1.13636	2764.6	608212
881	776161	683797841	29.6816	9.5865	2.94498	1.13507	2767.7	609595
882	777924	686128968	29.6985	9.5901	2.94547	1.13379	2770.9	610980
883	779689	688465387	29.7153	9.5937	2.94596	1.13250	2774.0	612366
884	781456	690807104	29.7321	9.5973	2.94645	1.13122	2777.2	613754
885	783225	693154125	29.7489	9.6010	2.94694	1.12994	2780.3	615143
886	784996	695506456	29.7658	9.6046	2.94743	1.12867	2783.5	616534
887	786769	697864103	29.7825	9.6082	2.94792	1.12740	2786.6	617927
888	788544	700227072	29.7993	9.6118	2.94841	1.12613	2789.7	619321
889	790321	702595369	29.8161	9.6154	2.94890	1.12486	2792.9	620717
890	792100	704969000	29.8329	9.6190	2.94939	1.12360	2796.0	622114
891	793881	707347971	29.8496	9.6226	2.94988	1.12233	2799.2	623513
892	795664	709732288	29.8664	9.6262	2.95036	1.12108	2802.3	624913
893	797449	712121957	29.8831	9.6298	2.95085	1.11982	2805.4	626315
894	799236	714516984	29.8998	9.6334	2.95134	1.11857	2808.6	627718
895	801025	716917375	29.9166	9.6370	2.95182	1.11732	2811.7	629124
896	802816	719323136	29.9333	9.6406	2.95231	1.11607	2814.9	630530
897	804609	721734273	29.9500	9.6442	2.95279	1.11483	2818.0	631938
898	806404	724150792	29.9666	9.6477	2.95328	1.11359	2821.2	633348
899	808201	726572699	29.9833	9.6513	2.95376	1.11235	2824.3	634760

Squares, Cubes, Square Roots, Cube Roots, Logarithms, Reciprocals, Circumferences and Circular Areas of Nos. from 1 to 1000

No.	Square	Cube	Square Root	Cube Root	Log.	1000 x Recip.	No. = Dia. Circum.	No. = Dia. Area
900	810000	729000000	30.0000	9.6549	2.95424	1.11111	2827.4	636173
901	811801	731432701	30.0167	9.6585	2.95472	1.10988	2830.6	637587
902	813604	733870808	30.0333	9.6620	2.95521	1.10865	2833.7	639003
903	815409	736314327	30.0500	9.6656	2.95569	1.10742	2836.9	640421
904	817216	738763264	30.0666	9.6692	2.95617	1.10619	2840.0	641840
905	819025	741217625	30.0832	9.6727	2.95665	1.10497	2843.1	643261
906	820836	743677416	30.0998	9.6763	2.95713	1.10375	2846.3	644683
907	822649	746142643	30.1164	9.6799	2.95761	1.10254	2849.4	646107
908	824464	748613312	30.1330	9.6834	2.95809	1.10132	2852.6	647533
909	826281	751089429	30.1496	9.6870	2.95856	1.10011	2855.7	648960
910	828100	753571000	30.1662	9.6905	2.95904	1.09890	2858.8	650388
911	829921	756058031	30.1828	9.6941	2.95952	1.09769	2862.0	651818
912	831744	758550528	30.1993	9.6976	2.95999	1.09649	2865.1	653250
913	833569	761048497	30.2159	9.7012	2.96047	1.09529	2868.3	654684
914	835396	763551944	30.2324	9.7047	2.96095	1.09409	2871.4	656118
915	837225	766060875	30.2490	9.7082	2.96142	1.09290	2874.6	657555
916	839056	768575296	30.2655	9.7118	2.96190	1.09170	2877.7	658993
917	840889	771095213	30.2820	9.7153	2.96237	1.09051	2880.8	660433
918	842724	773620632	30.2985	9.7188	2.96284	1.08932	2884.0	661874
919	844561	776151559	30.3150	9.7224	2.96332	1.08814	2887.1	663317
920	846400	778688000	30.3315	9.7259	2.96379	1.08696	2890.3	664761
921	848241	781229961	30.3480	9.7294	2.96426	1.08578	2893.4	666207
922	850084	783777448	30.3645	9.7329	2.96473	1.08460	2896.5	667654
923	851929	786330467	30.3809	9.7364	2.96520	1.08342	2899.7	669103
924	853776	788889024	30.3974	9.7400	2.96567	1.08225	2902.8	670554
925	855625	791453125	30.4138	9.7435	2.96614	1.08108	2906.0	672006
926	857476	794022776	30.4302	9.7470	2.96661	1.07991	2909.1	673460
927	859329	796597983	30.4467	9.7505	2.96708	1.07875	2912.3	674915
928	861184	799178752	30.4631	9.7540	2.96755	1.07759	2915.4	676372
929	863041	801765089	30.4795	9.7575	2.96802	1.07643	2918.5	677831
930	864900	804357000	30.4959	9.7610	2.96848	1.07527	2921.7	679291
931	866761	806954491	30.5123	9.7645	2.96895	1.07411	2924.8	680752
932	868624	809557568	30.5287	9.7680	2.96942	1.07296	2928.0	682216
933	870489	812166237	30.5450	9.7715	2.96988	1.07181	2931.1	683680
934	872356	814780504	30.5614	9.7750	2.97035	1.07066	2934.2	685147
935	874225	817400375	30.5778	9.7785	2.97081	1.06952	2937.4	686615
936	876096	820025856	30.5941	9.7819	2.97128	1.06838	2940.5	688084
937	877969	822656953	30.6105	9.7854	2.97174	1.06724	2943.7	689555
938	879844	825293672	30.6268	9.7889	2.97220	1.06610	2946.8	691028
939	881721	827936019	30.6431	9.7924	2.97267	1.06496	2950.0	692502
940	883600	830584000	30.6594	9.7959	2.97313	1.06383	2953.1	693978
941	885481	833237621	30.6757	9.7993	2.97359	1.06270	2956.2	695455
942	887364	835896888	30.6920	9.8028	2.97405	1.06157	2959.4	696934
943	889249	838561807	30.7083	9.8063	2.97451	1.06045	2962.5	698415
944	891136	841232384	30.7246	9.8097	2.97497	1.05932	2965.7	699897
945	893025	843908625	30.7409	9.8132	2.97543	1.05820	2968.8	701380
946	894916	846590536	30.7571	9.8167	2.97589	1.05708	2971.9	702865
947	896809	849278123	30.7734	9.8201	2.97635	1.05597	2975.1	704352
948	898704	851971392	30.7896	9.8236	2.97681	1.05485	2978.2	705840
949	900601	854670349	30.8058	9.8270	2.97727	1.05374	2981.4	707330

Squares, Cubes, Square Roots, Cube Roots, Logarithms, Reciprocals, Circumferences and Circular Areas of Nos. from 1 to 1000

No.	Square	Cube	Square Root	Cube Root	Log.	1000 x Recip.	No. = Dia. Circum.	No. = Dia. Area
950	902500	857375000	30.8221	9.8305	2.97772	1.05263	2984.5	708822
951	904401	860085351	30.8383	9.8339	2.97818	1.05152	2987.7	710315
952	906304	862801408	30.8545	9.8374	2.97864	1.05042	2990.8	711809
953	908209	865523177	30.8707	9.8408	2.97909	1.04932	2993.9	713306
954	910116	868250664	30.8869	9.8443	2.97955	1.04822	2997.1	714803
955	912025	870983875	30.9031	9.8477	2.98000	1.04712	3000.2	716303
956	913936	873722816	30.9192	9.8511	2.98046	1.04603	3003.4	717804
957	915849	876467493	30.9354	9.8546	2.98091	1.04493	3006.5	719306
958	917764	879217912	30.9516	9.8580	2.98137	1.04384	3009.6	720810
959	919681	881974079	30.9677	9.8614	2.98182	1.04275	3012.8	722316
960	921600	884736000	30.9839	9.8648	2.98227	1.04167	3015.9	723823
961	923521	887503681	31.0000	9.8683	2.98272	1.04058	3019.1	725332
962	925444	890277128	31.0161	9.8717	2.98318	1.03950	3022.2	726842
963	927369	893056347	31.0322	9.8751	2.98363	1.03842	3025.4	728354
964	929296	895841344	31.0483	9.8785	2.98408	1.03734	3028.5	729867
965	931225	898632125	31.0644	9.8819	2.98453	1.03627	3031.6	731382
966	933156	901428696	31.0805	9.8854	2.98498	1.03520	3034.8	732899
967	935089	904231063	31.0966	9.8888	2.98543	1.03413	3037.9	734417
968	937024	907039232	31.1127	9.8922	2.98588	1.03306	3041.1	735937
969	938961	909853209	31.1288	9.8956	2.98632	1.03199	3044.2	737458
970	940900	912673000	31.1448	9.8990	2.98677	1.03093	3047.3	738981
971	942841	915498611	31.1609	9.9024	2.98722	1.02987	3050.5	740506
972	944784	918330048	31.1769	9.9058	2.98767	1.02881	3053.6	742032
973	946729	921167317	31.1929	9.9092	2.98811	1.02775	3056.8	743559
974	948676	924010424	31.2090	9.9126	2.98856	1.02669	3059.9	745088
975	950625	926859375	31.2250	9.9160	2.98900	1.02564	3063.1	746619
976	952576	929714176	31.2410	9.9194	2.98945	1.02459	3066.2	748151
977	954529	932574833	31.2570	9.9227	2.98989	1.02354	3069.3	749685
978	956484	935441352	31.2730	9.9261	2.99034	1.02249	3072.5	751221
979	958441	938313739	31.2890	9.9295	2.99078	1.02145	3075.6	752758
980	960400	941192000	31.3050	9.9329	2.99123	1.02041	3078.8	754296
981	962361	944076141	31.3209	9.9363	2.99167	1.01937	3081.9	755837
982	964324	946966168	31.3369	9.9396	2.99211	1.01833	3085.0	757378
983	966289	949862087	31.3528	9.9430	2.99255	1.01729	3088.2	758922
984	968256	952763904	31.3688	9.9464	2.99300	1.01626	3091.3	760466
985	970225	955671625	31.3847	9.9497	2.99344	1.01523	3094.5	762013
986	972196	958585256	31.4006	9.9531	2.99388	1.01420	3097.6	763561
987	974169	961504803	31.4166	9.9565	2.99432	1.01317	3100.8	765111
988	976144	964430272	31.4325	9.9598	2.99476	1.01215	3103.9	766662
989	978121	967361669	31.4484	9.9632	2.99520	1.01112	3107.0	768214
990	980100	970299000	31.4643	9.9666	2.99564	1.01010	3110.2	769769
991	982081	973242271	31.4802	9.9699	2.99607	1.00908	3113.3	771325
992	984064	976191488	31.4960	9.9733	2.99651	1.00806	3116.5	772882
993	986049	979146657	31.5119	9.9766	2.99695	1.00705	3119.6	774441
994	988036	982107784	31.5278	9.9800	2.99739	1.00604	3122.7	776002
995	990025	985074875	31.5436	9.9833	2.99782	1.00503	3125.9	777564
996	992016	988047936	31.5595	9.9866	2.99826	1.00402	3129.0	779128
997	994009	991026973	31.5753	9.9900	2.99870	1.00301	3132.2	780693
998	996004	994011992	31.5911	9.9933	2.99913	1.00200	3135.3	782260
999	998001	997002999	31.6070	9.9967	2.99957	1.00100	3138.5	783828

DISCOUNT TABLE

Discount, Per Cent.			Equivalent	Net	Discount, Per Cent.			Equivalent	Net
25			.25	.75	30			.30	.70
25 and 2½			.26875	.73125	30 and 2½			.3175	.6825
25	2½ and	2½	.2870	.7130	30	2½ and	2½	.3346	.6654
25	2½	5	.3053	.6947	30	2½	5	.3516	.6484
25	2½	7½	.3236	.6764	30	2½	7½	.3687	.6313
25	2½	10	.3419	.6581	30	2½	10	.38575	.61425
25	5		.2875	.7125	30	5		.335	.665
25	5	2½	.3053	.6947	30	5	2½	.3516	.6484
25	5	5	.3231	.6769	30	5	5	.36825	.63175
25	5	7½	.3409	.6591	30	5	7½	.3849	.6151
25	5	10	.35875	.64125	30	5	10	.4015	.5985
25	7½		.30625	.69375	30	7½		.3525	.6475
25	7½	2½	.3236	.6764	30	7½	2½	.3687	.6313
25	7½	5	.3409	.6591	30	7½	5	.3849	.6151
25	7½	7½	.3583	.6417	30	7½	7½	.4009	.5991
25	7½	10	.3756	.6244	30	7½	10	.41725	.58275
25	10		.3250	.6750	30	10		.37	.63
25	10	2½	.3419	.6581	30	10	2½	.38575	.61425
25	10	5	.35875	.64125	30	10	5	.4015	.5985
25	10	7½	.3756	.6244	30	10	7½	.41725	.58275
25	10	10	.3925	.6075	30	10	10	.433	.567
27½			.275	.725	32½			.325	.675
27½	2½		.2931	.7069	32½	2½		.3419	.6581
27½	2½	2½	.3108	.6892	32½	2½	2½	.3583	.6417
27½	2½	5	.3285	.6715	32½	2½	5	.3748	.6252
27½	2½	7½	.3461	.6539	32½	2½	7½	.3912	.6088
27½	2½	10	.3638	.6362	32½	2½	10	.4077	.5923
27½	5		.31125	.68875	32½	5		.35875	.64125
27½	5	2½	.3285	.6715	32½	5	2½	.3748	.6252
27½	5	5	.3457	.6543	32½	5	5	.3908	.6092
27½	5	7½	.3629	.6371	32½	5	7½	.4068	.5932
27½	5	10	.3801	.6199	32½	5	10	.4229	.5771
27½	7½		.3294	.6706	32½	7½		.3756	.6244
27½	7½	2½	.3461	.6539	32½	7½	2½	.3912	.6088
27½	7½	5	.3629	.6371	32½	7½	5	.4068	.5932
27½	7½	7½	.3797	.6203	32½	7½	7½	.4225	.5775
27½	7½	10	.3964	.6036	32½	7½	10	.4381	.5619
27½	10		.3475	.6525	32½	10		.3925	.6075
27½	10	2½	.3638	.6362	32½	10	2½	.4077	.5923
27½	10	5	.3801	.6199	32½	10	5	.4229	.5771
27½	10	7½	.3965	.6035	32½	10	7½	.4381	.5619
27½	10	10	.41275	.58725	32½	10	10	.45325	.54675

DISCOUNT TABLE—Continued

Discount, Per Cent.			Equivalent	Net	Discount, Per Cent.			Equivalent	Net
35			.35	.65	40			.40	.60
35 and 2½			.36625	.63375	40 and 2½			.415	.585
35	2½	and 2½	.3821	.6179	40	2½	and 2½	.4296	.5704
35	2½	5	.3979	.6021	40	2½	5	.44425	.55575
35	2½	7½	.4138	.5862	40	2½	7½	.4589	.5411
35	2½	10	.4296	.5704	40	2½	10	.4735	.5265
35	5		.3825	.6175	40	5		.43	.57
35	5	2½	.3979	.6021	40	5	2½	.44425	.55575
35	5	5	.4134	.5866	40	5	5	.4585	.5415
35	5	7½	.4288	.5712	40	5	7½	.47275	.52725
35	5	10	.44425	.55575	40	5	10	.487	.513
35	7½		.39875	.60125	40	7½		.445	.555
35	7½	2½	.4138	.5862	40	7½	2½	.4589	.5411
35	7½	5	.4288	.5712	40	7½	5	.47275	.52725
35	7½	7½	.4438	.5562	40	7½	7½	.4866	.5134
35	7½	10	.4589	.5411	40	7½	10	.5005	.4995
35	10		.415	.585	40	10		.46	.54
35	10	2½	.4296	.5704	40	10	2½	.4735	.5265
35	10	5	.44425	.55575	40	10	5	.487	.513
35	10	7½	.4589	.5411	40	10	7½	.5005	.4995
35	10	10	.4735	.5265	40	10	10	.524	.486
37½			.375	.625	42½			.425	.575
37½	2½		.3906	.6094	42½	2½		.4394	.5606
37½	2½	2½	.4059	.5941	42½	2½	2½	.4534	.5466
37½	2½	5	.4211	.5789	42½	2½	5	.4674	.5326
37½	2½	7½	.4363	.5637	42½	2½	7½	.4814	.5186
37½	2½	10	.4516	.5484	42½	2½	10	.4954	.5046
37½	5		.40625	.59375	42½	5		.45375	.54625
37½	5	2½	.4211	.5789	42½	5	2½	.4674	.5326
37½	5	5	.4359	.5641	42½	5	5	.4811	.5189
37½	5	7½	.4508	.5492	42½	5	7½	.4947	.5053
37½	5	10	.4656	.5344	42½	5	10	.5084	.4916
37½	7½		.4219	.5781	42½	7½		.4681	.5319
37½	7½	2½	.4363	.5637	42½	7½	2½	.4814	.5186
37½	7½	5	.4508	.5492	42½	7½	5	.4947	.5053
37½	7½	7½	.4652	.5348	42½	7½	7½	.508	.492
37½	7½	10	.4797	.5203	42½	7½	10	.5213	.4787
37½	10		.4375	.5625	42½	10		.4825	.5175
37½	10	2½	.4516	.5484	42½	10	2½	.4954	.5046
37½	10	5	.4656	.5344	42½	10	5	.5084	.4916
37½	10	7½	.4797	.5203	42½	10	7½	.5213	.4787
37½	10	10	.49375	.50625	42½	10	10	.53425	.46575

DISCOUNT TABLE—Continued

Discount, Per Cent.	Equivalent	Net	Discount, Per Cent.	Equivalent	Net
45	.45	.55	50	.50	.50
45 and 2½	.46375	.53625	50 and 2½	.5125	.4875
45 2½ and 2½	.4772	.5228	50 2½ and 2½	.5247	.4753
45 2½ 5	.4906	.5094	50 2½ 5	.5369	.4631
45 2½ 7½	.504	.496	50 2½ 7½	.5491	.4509
45 2½ 10	.5174	.4826	50 2½ 10	.56125	.43875
45 5	.4775	.5225	50 5	.525	.475
45 5 2½	.4906	.5094	50 5 2½	.5369	.4631
45 5 5	.5036	.4964	50 5 5	.54875	.45125
45 5 7½	.5167	.4833	50 5 7½	.5606	.4394
45 5 10	.52975	.47025	50 5 10	.5725	.4275
45 7½	.49125	.50875	50 7½	.5375	.4625
45 7½ 2½	.504	.496	50 7½ 2½	.5491	.4509
45 7½ 5	.5167	.4833	50 7½ 5	.5606	.4394
45 7½ 7½	.5294	.4706	50 7½ 7½	.5722	.4278
45 7½ 10	.5421	.4579	50 7½ 10	.58375	.41625
45 10	.505	.495	50 10	.55	.45
45 10 2½	.5174	.4826	50 10 2½	.56125	.43875
45 10 5	.52975	.47025	50 10 5	.5725	.4275
45 10 7½	.5421	.4579	50 10 7½	.58375	.41625
45 10 10	.5545	.4455	50 10 10	.595	.405
47½	.475	.525	52½	.525	.472
47½ 2½	.4881	.5119	52½ 2½	.5369	.4631
47½ 2½ 2½	.5009	.4991	52½ 2½ 2½	.5485	.4515
47½ 2½ 5	.5137	.4863	52½ 2½ 5	.56	.44
47½ 2½ 7½	.5265	.4735	52½ 2½ 7½	.5716	.4284
47½ 2½ 10	.5393	.4607	52½ 2½ 10	.5832	.4168
47½ 5	.50125	.49875	52½ 5	.54875	.45125
47½ 5 2½	.5137	.4863	52½ 5 2½	.56	.44
47½ 5 5	.5262	.4738	52½ 5 5	.5713	.4287
47½ 5 7½	.5386	.4614	52½ 5 7½	.5826	.4174
47½ 5 10	.5511	.4489	52½ 5 10	.5939	.4061
47½ 7½	.5144	.4856	52½ 7½	.5606	.4394
47½ 7½ 2½	.5265	.4735	52½ 7½ 2½	.5716	.4284
47½ 7½ 5	.5387	.4613	52½ 7½ 5	.5826	.4174
47½ 7½ 7½	.5508	.4492	52½ 7½ 7½	.5936	.4064
47½ 7½ 10	.5629	.4371	52½ 7½ 10	.6046	.3954
47½ 10	.5275	.4725	52½ 10	.5725	.4275
47½ 10 2½	.5393	.4607	52½ 10 2½	.5832	.4168
47½ 10 5	.5511	.4489	52½ 10 5	.5939	.4061
47½ 10 7½	.5629	.4371	52½ 10 7½	.6046	.3954
47½ 10 10	.57475	.42525	52½ 10 10	.61525	.38475

DISCOUNT TABLE—Continued

Discount, Per Cent.	Equivalent	Net	Discount, Per Cent.	Equivalent	Net
55	.55	.45	60	.60	.40
55 and 2½	.56125	.43875	60 and 2½	.61	.39
55 2½ and 2½	.5722	.4278	60 2½ and 2½	.61975	.38025
55 2½ 5	.5832	.4168	60 2½ 5	.6295	.3705
55 2½ 7½	.5942	.4058	60 2½ 7½	.63925	.36075
55 2½ 10	.6051	.3949	60 2½ 10	.649	.351
55 5	.5725	.4275	60 5	.62	.38
55 5 2½	.5832	.4168	60 5 2½	.6295	.3705
55 5 5	.5939	.4061	60 5 5	.639	.361
55 5 7½	.6046	.3954	60 5 7½	.6485	.3515
55 5 10	.61525	.38475	60 5 10	.658	.342
55 7½	.58375	.41625	60 7½	.63	.37
55 7½ 2½	.5942	.4058	60 7½ 2½	.63925	.36075
55 7½ 5	.6046	.3954	60 7½ 5	.6485	.3515
55 7½ 7½	.615	.385	60 7½ 7½	.65775	.34225
55 7½ 10	.6254	.3746	60 7½ 10	.667	.333
55 10	.595	.405	60 10	.64	.36
55 10 2½	.6051	.3949	60 10 2½	.649	.351
55 10 5	.61525	.38475	60 10 5	.658	.342
55 10 7½	.6254	.3746	60 10 7½	.667	.333
55 10 10	.6355	.3645	60 10 10	.676	.324
57½	.575	.425	62½	.625	.375
57½ 2½	.5856	.4144	62½ 2½	.6344	.3656
57½ 2½ 2½	.596	.404	62½ 2½ 2½	.6435	.3565
57½ 2½ 5	.6063	.3937	62½ 2½ 5	.6527	.3473
57½ 2½ 7½	.6167	.3833	62½ 2½ 7½	.6618	.3382
57½ 2½ 10	.6271	.3729	62½ 2½ 10	.6709	.3291
57½ 5	.5962	.40375	62½ 5	.64375	.35625
57½ 5 2½	.60635	.3937	62½ 5 2½	.6527	.3473
57½ 5 5	.6164	.3836	62½ 5 5	.6616	.3384
57½ 5 7½	.6265	.3735	62½ 5 7½	.6705	.3295
57½ 5 10	.6366	.3634	62½ 5 10	.6794	.3206
57½ 7½	.6069	.3931	62½ 7½	.6531	.3469
57½ 7½ 2½	.6167	.3833	62½ 7½ 2½	.6618	.3382
57½ 7½ 5	.6265	.3735	62½ 7½ 5	.6705	.3295
57½ 7½ 7½	.6364	.3636	62½ 7½ 7½	.6791	.3209
57½ 7½ 10	.6462	.3538	62½ 7½ 10	.6878	.3122
57½ 10	.6175	.3825	62½ 10	.6625	.3375
57½ 10 2½	.6271	.3729	62½ 10 2½	.6709	.3291
57½ 10 5	.6366	.3634	62½ 10 5	.6794	.3206
57½ 10 7½	.6462	.3538	62½ 10 7½	.6878	.3122
57½ 10 10	.6557	.34425	62½ 10 10	.69625	.30375

DISCOUNT TABLE—Continued

Discount, Per Cent.	Equivalent	Net	Discount, Per Cent.	Equivalent	Net
65	.65	.35	70	.70	.30
65 and 2½	.65875	.34125	70 and 2½	.7075	.2925
65 2½ and 2½	.6673	.3327	70 2½ and 2½	.7148	.2852
65 2½ 5	.6758	.3242	70 2½ 5	.7221	.2779
65 2½ 7½	.6843	.3157	70 2½ 7½	.7294	.2706
65 2½ 10	.6929	.3071	70 2½ 10	.73675	.26325
65 5	.6675	.3325	70 5	.715	.285
65 5 2½	.6758	.3242	70 5 2½	.7221	.2779
65 5 5	.6841	.3159	70 5 5	.72925	.27075
66 5 7½	.6924	.3076	70 5 7½	.7364	.2636
65 5 10	.70075	.29925	70 5 10	.7435	.2565
65 7½	.67625	.32375	70 7½	.7225	.2775
65 7½ 2½	.6843	.3157	70 7½ 2½	.7294	.2706
65 7½ 5	.6924	.3076	70 7½ 5	.7364	.2636
65 7½ 7½	.7005	.2995	70 7½ 7½	.7433	.2567
65 7½ 10	.7086	.2914	70 7½ 10	.75025	.24975
65 10	.685	.315	70 10	.73	.27
65 10 2½	.6929	.3071	70 10 2½	.73675	.26325
65 10 5	.70075	.29925	70 10 5	.7435	.2565
65 10 7½	.7086	.2914	70 10 7½	.75025	.24975
65 10 10	.7165	.2835	70 10 10	.757	.243
67½	.675	.325	72½	.725	.275
67½ 2½	.6831	.3169	72½ 2½	.7319	.2681
67½ 2½ 2½	.691	.309	72½ 2½ 2½	.7386	.2614
67½ 2½ 5	.699	.301	72½ 2½ 5	.7452	.2548
67½ 2½ 7½	.7069	.2931	72½ 2½ 7½	.752	.248
67½ 2½ 10	.7148	.2852	72½ 2½ 10	.7587	.2413
67½ 5	.69125	.30875	72½ 5	.73875	.26125
67½ 5 2½	.699	.301	72½ 5 2½	.7453	.2547
67½ 5 5	.7067	.2933	72½ 5 5	.7518	.2482
67½ 5 7½	.7144	.2856	72½ 5 7½	.7583	.2417
67½ 5 10	.7221	.2779	72½ 5 10	.7649	.2351
67½ 7½	.6994	.3006	72½ 7½	.7456	.2544
67½ 7½ 2½	.7069	.2931	72½ 7½ 2½	.752	.248
67½ 7½ 5	.7144	.2856	72½ 7½ 5	.7583	.2417
67½ 7½ 7½	.7219	.2781	72½ 7½ 7½	.7647	.2353
67½ 7½ 10	.7294	.2706	72½ 7½ 10	.7711	.2289
67½ 10	.7075	.2925	72½ 10	.7525	.2475
67½ 10 2½	.7148	.2852	72½ 10 2½	.7587	.2413
67½ 10 5	.7221	.2779	72½ 10 5	.7649	.2351
67½ 10 7½	.7294	.2706	72½ 10 7½	.7711	.2289
67½ 10 10	.73675	.26325	72½ 10 10	.77725	.22275

DISCOUNT TABLE—Concluded

Discount, Per Cent.			Equivalent	Net	Discount, Per Cent.			Equivalent	Net
75			.75	.25	77½	7½		.7919	.2081
75 and 2½			.75625	.24375	77½	7½	2½	.7971	.2029
75	2½	and 2½	.76234	.23766	77½	7½	5	.8023	.1977
75	2½	5	.7684	.2316	77½	7½	7½	.8075	.1925
75	2½	7½	.7745	.2255	77½	7½	10	.8127	.1873
75	2½	10	.7806	.2194	77½	10		.7975	.2025
75	5		.7625	.2375	77½	10	2½	.8026	.1974
75	5	2½	.7684	.2316	77½	10	5	.8076	.1924
75	5	5	.7744	.2256	77½	10	7½	.8127	.1873
75	5	7½	.7803	.2197	77½	10	10	.81775	.18225
75	5	10	.78625	.21375					
75	7½		.76875	.23125	80			.80	.20
75	7½	2½	.7745	.2255	80 and 2½			.805	.1950
75	7½	5	.7803	.2197	80	2½	and 2½	.8099	.1901
75	7½	7½	.7861	.2139	80	2½	5	.8147	.1853
75	7½	10	.7919	.2081	80	2½	7½	.8197	.1803
75	10		.775	.225	80	2½	10	.8245	.1755
75	10	2½	.7806	.2194	80	5		.81	.19
75	10	5	.78625	.21375	80	5	2½	.8148	.1852
75	10	7½	.7919	.2081	80	5	5	.8195	.1805
75	10	10	.7975	.2025	80	5	7½	.8243	.1757
					80	5	10	.829	.1710
77½			.775	.225	80	7½		.815	.1850
77½	2½		.7806	.2194	80	7½	2½	.8196	.1804
77½	2½	2½	.7861	.2139	80	7½	5	.8242	.1758
77½	2½	5	.7916	.2084	80	7½	7½	.8289	.1711
77½	2½	7½	.7971	.2029	80	7½	10	.8335	.1665
77½	2½	10	.8026	.1974	80	10		.82	.18
77½	5		.78625	.21375	80	10	2½	.8245	.1755
77½	5	2½	.7916	.2084	80	10	5	.829	.1710
77½	5	5	.7969	.2031	80	10	7½	.8335	.1665
77½	5	7½	.8023	.1977	80	10	10	.838	.162
77½	5	10	.8076	.1924					

Natural Trigonometrical Functions

Deg.	Min.	Sine	Vers. Cos.	Cosecant	Tang.	Cotang.	Secant	Vers. Sin.	Cosine	Min.	Deg.
0	0	.00000	1.0000	Infin.	.00000	Infin.	1.0000	.00000	1.0000		90
	10	.00291	.99709	343.77	.00291	343.77	1.0000	.00000	.99999	50	
	20	.00582	.99418	171.89	.00582	171.88	1.0000	.00002	.99998	40	
	30	.00873	.99127	114.59	.00873	114.59	1.0000	.00004	.99996	30	
	40	.01163	.98836	85.946	.01164	85.940	1.0001	.00007	.99993	20	
	50	.01454	.98546	68.757	.01454	68.750	1.0001	.00010	.99989	10	
1	0	.01745	.98255	57.299	.01745	57.290	1.0001	.00015	.99985		89
	10	.02036	.97964	49.114	.02036	49.104	1.0002	.00021	.99979	50	
	20	.02327	.97673	42.976	.02327	42.964	1.0003	.00027	.99973	40	
	30	.02618	.97382	38.201	.02618	38.188	1.0003	.00034	.99966	30	
	40	.02908	.97091	34.382	.02910	34.368	1.0004	.00042	.99958	20	
	50	.03199	.96801	31.257	.03201	31.241	1.0005	.00051	.99949	10	
2	0	.03490	.96510	28.654	.03492	28.636	1.0006	.00061	.99939		88
	10	.03781	.96219	26.450	.03783	26.432	1.0007	.00071	.99928	50	
	20	.04071	.95929	24.562	.04075	24.542	1.0008	.00083	.99917	40	
	30	.04362	.95638	22.925	.04366	22.904	1.0009	.00095	.99905	30	
	40	.04652	.95347	21.494	.04657	21.470	1.0011	.00108	.99892	20	
	[illegible]	.04943	.95057	20.230	.04949	20.206	1.0012	.00122	.99878	10	
3	0	.05234	.94766	19.107	.05241	19.081	1.0014	.00137	.99863		87
	10	.05524	.94476	18.103	.05532	18.075	1.0015	.00153	.99847	50	
	20	.05814	.94185	17.198	.05824	17.169	1.0017	.00169	.99831	40	
	30	.06105	.93895	16.380	.06116	16.350	1.0019	.00186	.99813	30	
	40	.06395	.93605	15.637	.06408	15.605	1.0020	.00205	.99795	20	
	50	.06685	.93314	14.958	.06700	14.924	1.0022	.00224	.99776	10	
4	0	.06976	.93024	14.335	.06993	14.301	1.0024	.00243	.99756		86
	10	.07266	.92734	13.763	.07285	13.727	1.0026	.00264	.99736	50	
	20	.07556	.92444	13.235	.07577	13.197	1.0029	.00286	.99714	40	
	30	.07846	.92154	12.745	.07870	12.706	1.0031	.00308	.99692	30	
	40	.08136	.91864	12.291	.08163	12.250	1.0033	.00331	.99668	20	
	50	.08426	.91574	11.868	.08456	11.826	1.0036	.00356	.99644	10	
5	[illegible]	.08715	.91284	11.474	.08749	11.430	1.0038	.00380	.99619		85
	10	.09005	.90995	11.104	.09042	11.059	1.0041	.00406	.99594	50	
	20	.09295	.90705	10.758	.09335	10.712	1.0043	.00433	.99567	40	
	30	.09584	.90415	10.433	.09629	10.385	1.0046	.00460	.99540	30	
	40	.09874	.90126	10.127	.09922	10.078	1.0049	.00489	.99511	20	
	50	.10163	.89836	9.8391	.10216	9.7882	1.0052	.00518	.99482	10	
6	0	.10453	.89547	9.5668	.10510	9.5144	1.0055	.00548	.99452		84
	10	.10742	.89258	9.3092	.10805	9.2553	1.0058	.00579	.99421	50	
	20	.11031	.88969	9.0651	.11099	9.0098	1.0061	.00110	.99390	40	
	30	.11320	.88680	8.8337	.11393	8.7769	1.0065	.00643	.99357	30	
	40	.11609	.88391	8.6138	.11688	8.5555	1.0068	.00676	.99324	20	
	50	.11898	.88102	8.4046	.11983	8.3449	1.0071	.00710	.99290	10	
7	0	.12187	.87813	8.2055	.12278	8.1443	1.0075	.00745	.99255		83
	10	.12476	.87524	8.0156	.12574	7.9530	1.0079	.00781	.99219	50	
	20	.12764	.87236	7.8344	.12869	7.7703	1.0082	.00818	.99182	40	
	30	.13053	.86947	7.6613	.13165	7.5957	1.0086	.00855	.99144	30	
	40	.13341	.86659	7.4957	.13461	7.4287	1.0090	.00894	.99106	20	
	50	.13629	.86371	7.3372	.13757	7.2687	1.0094	.00933	.99067	10	
8	0	.13917	.86083	7.1853	.14054	7.1154	1.0098	.00973	.99027		82
	10	.14205	.85795	7.0396	.14351	6.9682	1.0102	.01014	.98986	50	
	20	.14493	.85507	6.8998	.14648	6.8269	1.0107	.01056	.98944	40	
	30	.14781	.85219	6.7655	.14945	6.6911	1.0111	.01098	.98901	30	
	40	.15068	.84931	6.6363	.15243	6.5605	1.0115	.01142	.98858	20	
	50	.15356	.84644	6.5121	.15540	6.4348	1.0120	.01186	.98814	10	
9	0	.15643	.84356	6.3924	.15838	6.3137	1.0125	.01231	.98769		81
		Cosine	Vers. Sin.	Secant	Cotang.	Tangent	Cosecant	Vers. Cos.	Sine		

Natural Trigonometrical Functions—Continued

Deg.	Min.	Sine	Vers. Cos.	Cosecant	Tang.	Cotang.	Secant	Vers. Sin.	Cosine	Min.	Deg.
9	0	.15643	.84356	6.3924	.15838	6.3137	1.0125	.01231	.98769		81
	10	.15931	.84069	6.2772	.16137	6.1970	1.0129	.01277	.98723	50	
	20	.16218	.83782	6.1661	.16435	6.0844	1.0134	.01324	.98676	40	
	30	.16505	.83495	6.0588	.16734	5.9758	1.0139	.01371	.98628	30	
	40	.16791	.83208	5.9554	.17033	5.8708	1.0144	.01420	.98580	20	
	50	.17078	.82922	5.8554	.17333	5.7694	1.0149	.01469	.98531	10	
10	0	.17365	.82635	5.7588	.17633	5.6713	1.0154	.01519	.98481		80
	10	.17651	.82349	5.6653	.17933	5.5764	1.0159	.01570	.98430	50	
	20	.17937	.82062	5.5749	.18233	5.4845	1.0165	.01622	.98378	40	
	30	.18223	.81776	5.4874	.18534	5.3955	1.0170	.01674	.98325	30	
	40	.18509	.81490	5.4026	.18835	5.3093	1.0176	.01728	.98272	20	
	50	.18795	.81205	5.3205	.19136	5.2257	1.0181	.01782	.98218	10	
11	0	.19081	.80919	5.2408	.19438	5.1445	1.0187	.01837	.98163		79
	10	.19366	.80634	5.1636	.19740	5.0658	1.0193	.01893	.98107	50	
	20	.19652	.80348	5.0886	.20042	4.9894	1.0199	.01950	.98050	40	
	30	.19937	.80063	5.0158	.20345	4.9151	1.0205	.02007	.97992	30	
	40	.20222	.79778	4.9452	.20648	4.8430	1.0211	.02066	.97934	20	
	50	.20506	.79493	4.8765	.20952	4.7728	1.0217	.02125	.97875	10	
12	0	.20791	.79209	4.8097	.21256	4.7046	1.0223	.02185	.97815		78
	10	.21076	.78924	4.7448	.21560	4.6382	1.0230	.02246	.97754	50	
	20	.21360	.78640	4.6817	.21864	4.5736	1.0236	.02308	.97692	40	
	30	.21644	.78356	4.6202	.22169	4.5107	1.0243	.02370	.97630	30	
	40	.21928	.78072	4.5604	.22475	4.4494	1.0249	.02434	.97566	20	
	50	.22211	.77788	4.5021	.22781	4.3897	1.0256	.02498	.97502	10	
13	0	.22495	.77505	4.4454	.23087	4.3315	1.0263	.02563	.97437		77
	10	.22778	.77221	4.3901	.23393	4.2747	1.0270	.02629	.97371	50	
	20	.23061	.76938	4.3362	.23700	4.2193	1.0277	.02695	.97304	40	
	30	.23344	.76655	4.2836	.24008	4.1653	1.0284	.02763	.97237	30	
	40	.23627	.76373	4.2324	.24316	4.1127	1.0291	.02831	.97169	20	
	50	.23910	.76090	4.1824	.24624	4.0611	1.0299	.02900	.97099	10	
14	0	.24192	.75808	4.1336	.24933	4.0108	1.0306	.02970	.97029		76
	10	.24474	.75526	4.0859	.25242	3.9616	1.0314	.03041	.96959	50	
	20	.24756	.75244	4.0394	.25552	3.9136	1.0321	.03113	.96887	40	
	30	.25038	.74962	3.9939	.25862	3.8667	1.0329	.03185	.96815	30	
	40	.25319	.74680	3.9495	.26172	3.8208	1.0337	.03258	.96741	20	
	50	.25601	.74399	3.9061	.26483	3.7759	1.0345	.03332	.96667	10	
15	0	.25882	.74118	3.8637	.26795	3.7320	1.0353	.03407	.96592		75
	10	.26163	.73837	3.8222	.27107	3.6891	1.0361	.03483	.96517	50	
	20	.26443	.73556	3.7816	.27419	3.6470	1.0369	.03560	.96440	40	
	30	.26724	.73276	3.7420	.27732	3.6059	1.0377	.03637	.96363	30	
	40	.27004	.72996	3.7031	.28046	3.5656	1.0386	.03715	.96285	20	
	50	.27284	.72716	3.6651	.28360	3.5261	1.0394	.03794	.96206	10	
16	0	.27564	.72436	3.6279	.28674	3.4874	1.0403	.03874	.96126		74
	10	.27843	.72157	3.5915	.28990	3.4495	1.0412	.03964	.96045	50	
	20	.28122	.71877	3.5559	.29305	3.4124	1.0420	.04036	.95964	40	
	30	.28401	.71608	3.5209	.29621	3.3759	1.0429	.04118	.95882	30	
	40	.28680	.71320	3.4867	.29938	3.3402	1.0438	.04201	.95799	20	
	50	.28959	.71041	3.4532	.30255	3.3052	1.0448	.04285	.95715	10	
17	0	.29237	.70763	3.4203	.30573	3.2708	1.0457	.04369	.95630		73
	10	.29515	.70485	3.3881	.30891	3.2371	1.0466	.04455	.95545	50	
	20	.29793	.70207	3.3565	.31210	3.2041	1.0476	.04541	.95459	40	
	30	.30070	.69929	3.3255	.31530	3.1716	1.0485	.04628	.95372	30	
	40	.30348	.69652	3.2951	.31850	3.1397	1.0495	.04716	.95284	20	
	50	.30625	.69375	3.2653	.32171	3.1084	1.0505	.04805	.95195	10	
18	0	.30902	.69098	3.2361	.32492	3.0777	1.0515	.04894	.95106		72
		Cosine	Vers. Sin.	Secant	Cotang.	Tangent	Cosecant	Vers. Cos.	Sine		

Natural Trigonometrical Functions—Continued

Deg.	Min.	Sine	Vers. Cos.	Cosecant	Tang.	Cotang.	Secant	Vers. Sin.	Cosine	Min.	Deg.
18	0	.30902	.69098	3.2361	.32492	3.0777	1.0515	.04894	.95106		72
	10	.31178	.68822	3.2074	.32814	3.0475	1.0525	.04985	.95015	50	
	20	.31454	.68545	3.1792	.33136	3.0178	1.0535	.05076	.94924	40	
	30	.31730	.68269	3.1515	.33459	2.9887	1.0545	.05168	.94832	30	
	40	.32006	.67994	3.1244	.33783	2.9600	1.0555	.05260	.94740	20	
	50	.32282	.67718	3.0977	.34108	2.9319	1.0566	.05354	.94646	10	
19	0	.32557	.67443	3.0715	.34433	2.9042	1.0576	.05448	.94552		71
	10	.32832	.67168	3.0458	.34758	2.8770	1.0587	.05543	.94457	50	
	20	.33106	.66894	3.0206	.35085	2.8502	1.0598	.05639	.94361	40	
	30	.33381	.66619	2.9957	.35412	2.8239	1.0608	.05736	.94264	30	
	40	.33655	.66345	2.9713	.35739	2.7980	1.0619	.05833	.94167	20	
	50	.33928	.66071	2.9474	.36068	2.7725	1.0630	.05932	.94068	10	
20	0	.34202	.65798	2.9238	.36397	2.7475	1.0642	.06031	.93969		70
	10	.34475	.65525	2.9006	.36727	2.7228	1.0653	.06131	.93869	50	
	20	.34748	.65252	2.8778	.37057	2.6985	1.0664	.06231	.93769	40	
	30	.35021	.64979	2.8554	.37388	2.6746	1.0676	.06333	.93667	30	
	40	.35293	.64707	2.8334	.37720	2.6511	1.0688	.06435	.93565	20	
	50	.35565	.64435	2.8117	.38053	2.6279	1.0699	.06538	.93462	10	
21	0	.35837	.64163	2.7904	.38386	2.6051	1.0711	.06642	.93358		69
	10	.36108	.63892	2.7694	.38720	2.5826	1.0723	.06747	.93253	50	
	20	.36379	.63621	2.7488	.39055	2.5605	1.0736	.06852	.93148	40	
	30	.36650	.63350	2.7285	.39391	2.5386	1.0748	.06958	.93042	30	
	40	.36921	.63079	2.7085	.39727	2.5171	1.0760	.07065	.92935	20	
	50	.37191	.62809	2.6888	.40065	2.4960	1.0773	.07173	.92827	10	
22	0	.37461	.62539	2.6695	.40403	2.4751	1.0785	.07282	.92718		68
	10	.37730	.62270	2.6504	.40741	2.4545	1.0798	.07391	.92609	50	
	20	.37999	.62000	2.6316	.41081	2.4342	1.0811	.07501	.92499	40	
	30	.38268	.61732	2.6131	.41421	2.4142	1.0824	.07612	.92388	30	
	40	.38537	.61463	2.5949	.41762	2.3945	1.0837	.07724	.92276	20	
	50	.38805	.61195	2.5770	.42105	2.3750	1.0850	.07836	.92164	10	
23	0	.39073	.60927	2.5593	.42447	2.3558	1.0864	.07949	.92050		67
	10	.39341	.60659	2.5419	.42791	2.3369	1.0877	.08063	.91936	50	
	20	.39608	.60392	2.5247	.43136	2.3183	1.0891	.08178	.91822	40	
	30	.39875	.60125	2.5078	.43481	2.2998	1.0904	.08294	.91706	30	
	40	.40141	.59858	2.4912	.43827	2.2817	1.0918	.08410	.91590	20	
	50	.40408	.59592	2.4748	.44175	2.2637	1.0932	.08527	.91472	10	
24	0	.40674	.59326	2.4586	.44523	2.2460	1.0946	.08645	.91354		66
	10	.40939	.59061	2.4426	.44872	2.2286	1.0961	.08764	.91236	50	
	20	.41204	.58795	2.4269	.45222	2.2113	1.0975	.08884	.91116	40	
	30	.41469	.58531	2.4114	.45573	2.1943	1.0989	.09004	.90996	30	
	40	.41734	.58266	2.3961	.45924	2.1775	1.1004	.09125	.90875	20	
	50	.41998	.58002	2.3811	.46277	2.1609	1.1019	.09247	.90753	10	
25	0	.42262	.57738	2.3662	.46631	2.1445	1.1034	.09369	.90631		65
	10	.42525	.57475	2.3515	.46985	2.1283	1.1049	.09492	.90507	50	
	20	.42788	.57212	2.3371	.47341	2.1123	1.1064	.09617	.90383	40	
	30	.43051	.56949	2.3228	.47697	2.0965	1.1079	.09741	.90258	30	
	40	.43313	.56686	2.3087	.48055	2.0809	1.1095	.09867	.90133	20	
	50	.43575	.56424	2.2949	.48414	2.0655	1.1110	.09993	.90006	10	
26	0	.43837	.56163	2.2812	.48773	2.0503	1.1126	.10121	.89879		64
	10	.44098	.55902	2.2676	.49134	2.0352	1.1142	.10248	.89751	50	
	20	.44359	.55641	2.2543	.49495	2.0204	1.1158	.10377	.89623	40	
	30	.44620	.55380	2.2411	.49858	2.0057	1.1174	.10506	.89493	30	
	40	.44880	.55120	2.2282	.50222	1.9912	1.1190	.10637	.89363	20	
	50	.45140	.54860	2.2153	.50587	1.9768	1.1207	.10768	.89232	10	
27	0	.45399	.54601	2.2027	.50952	1.9626	1.1223	.10899	.89101		63
		Cosine	Vers. Sin.	Secant	Cotang.	Tangent	Cosecant	Vers. Cos.	Sine		

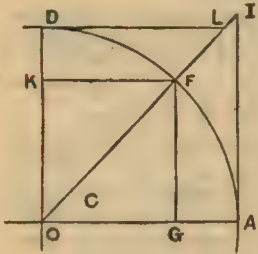
Natural Trigonometrical Functions—Continued

Deg.	Min.	Sine	Vers. Cos.	Cosecant	Tang.	Co-tang.	Secant	Vers. Sin.	Co-sine	Min.	Deg.
27	0	.45399	.54601	2.2027	.50952	1.9626	1.1223	.10899	.89101		63
	10	.45658	.54342	2.1902	.51319	1.9486	1.1240	.11032	.88968	50	
	20	.45917	.54083	2.1778	.51687	1.9347	1.1257	.11165	.88835	40	
	30	.46175	.53825	2.1657	.52057	1.9210	1.1274	.11299	.88701	30	
	40	.46433	.53567	2.1536	.52427	1.9074	1.1291	.11434	.88566	20	
	50	.46690	.53310	2.1418	.52798	1.8940	1.1308	.11569	.88431	10	
28	0	.46947	.53053	2.1300	.53171	1.8807	1.1326	.11705	.88295		62
	10	.47204	.52796	2.1185	.53545	1.8676	1.1343	.11842	.88158	50	
	20	.47460	.52540	2.1070	.53919	1.8546	1.1361	.11980	.88020	40	
	30	.47716	.52284	2.0957	.54295	1.8418	1.1379	.12118	.87882	30	
	40	.47971	.52029	2.0846	.54673	1.8291	1.1397	.12257	.87742	20	
	50	.48226	.51774	2.0735	.55051	1.8165	1.1415	.12397	.87603	10	
29	0	.48481	.51519	2.0627	.55431	1.8040	1.1433	.12538	.87462		61
	10	.48735	.51265	2.0519	.55812	1.7917	1.1452	.12679	.87320	50	
	20	.48989	.51011	2.0413	.56194	1.7795	1.1471	.12821	.87178	40	
	30	.49242	.50758	2.0308	.56577	1.7675	1.1489	.12964	.87035	30	
	40	.49495	.50505	2.0204	.56962	1.7555	1.1508	.13108	.86892	20	
	50	.49748	.50252	2.0101	.57348	1.7437	1.1528	.13252	.86748	10	
30	0	.50000	.50000	2.0000	.57735	1.7320	1.1547	.13397	.86602		60
	10	.50252	.49748	1.9900	.58123	1.7205	1.1566	.13543	.86457	50	
	20	.50503	.49497	1.9801	.58513	1.7090	1.1586	.13690	.86310	40	
	30	.50754	.49246	1.9703	.58904	1.6977	1.1606	.13837	.86163	30	
	40	.51004	.48996	1.9606	.59297	1.6864	1.1626	.13985	.86015	20	
	50	.51254	.48746	1.9510	.59691	1.6753	1.1646	.14134	.85866	10	
31	0	.51504	.48496	1.9416	.60086	1.6643	1.1666	.14283	.85717		59
	10	.51753	.48247	1.9322	.60483	1.6534	1.1687	.14433	.85566	50	
	20	.52002	.47998	1.9230	.60881	1.6425	1.1707	.14584	.85416	40	
	30	.52250	.47750	1.9139	.61280	1.6318	1.1728	.14736	.85264	30	
	40	.52498	.47502	1.9048	.61681	1.6212	1.1749	.14888	.85112	20	
	50	.52745	.47255	1.8959	.62083	1.6107	1.1770	.15041	.84959	10	
32	0	.52992	.47008	1.8871	.62487	1.6003	1.1792	.15195	.84805		58
	10	.53238	.46762	1.8783	.62892	1.5900	1.1813	.15350	.84650	50	
	20	.53484	.46516	1.8697	.63299	1.5798	1.1835	.15505	.84495	40	
	30	.53730	.46270	1.8611	.63707	1.5697	1.1857	.15661	.84339	30	
	40	.53975	.46025	1.8527	.64117	1.5596	1.1879	.15817	.84182	20	
	50	.54220	.45780	1.8443	.64528	1.5497	1.1901	.15975	.84025	10	
33	0	.54464	.45536	1.8361	.64941	1.5399	1.1924	.16133	.83867		57
	10	.54708	.45292	1.8279	.65355	1.5301	1.1946	.16292	.83708	50	
	20	.54951	.45049	1.8198	.65771	1.5204	1.1969	.16451	.83549	40	
	30	.55194	.44806	1.8118	.66188	1.5108	1.1992	.16611	.83388	30	
	40	.55436	.44564	1.8039	.66608	1.5013	1.2015	.16772	.83228	20	
	50	.55678	.44322	1.7960	.67028	1.4919	1.2039	.16934	.83066	10	
34	0	.55919	.44081	1.7883	.67451	1.4826	1.2062	.17096	.82904		56
	10	.56160	.43840	1.7806	.67875	1.4733	1.2086	.17259	.82741	50	
	20	.56401	.43599	1.7730	.68301	1.4641	1.2110	.17423	.82577	40	
	30	.56641	.43359	1.7655	.68728	1.4550	1.2134	.17587	.82413	30	
	40	.56880	.43120	1.7581	.69157	1.4460	1.2158	.17752	.82247	20	
	50	.57119	.42881	1.7507	.69588	1.4370	1.2183	.17918	.82082	10	
35	0	.57358	.42642	1.7434	.70021	1.4281	1.2208	.18085	.81915		55
	10	.57596	.42404	1.7362	.70455	1.4193	1.2233	.18252	.81748	50	
	20	.57833	.42167	1.7291	.70891	1.4106	1.2258	.18420	.81580	40	
	30	.58070	.41930	1.7220	.71329	1.4019	1.2283	.18588	.81411	30	
	40	.58307	.41693	1.7151	.71769	1.3933	1.2309	.18758	.81242	20	
	50	.58543	.41457	1.7081	.72211	1.3848	1.2335	.18928	.81072	10	
36	0	.58778	.41221	1.7013	.72654	1.3764	1.2361	.19098	.80902		54
		Co-sine	Vers. Sin.	Secant	Co-tang.	Tangent	Cosecant	Vers. Cos.	Sine		

Natural Trigonometrical Functions—Concluded

Deg.	Min.	Sine	Vers. Cos.	Cosecant	Tang.	Co-tang.	Secant	Vers. Sin.	Co-sine	Min.	Deg.
36	0	.58778	.41221	1.7013	.72654	1.3764	1.2361	.19098	.80902		54
	10	.59014	.40986	1.6945	.73100	1.3680	1.2387	.19270	.80730	50	
	20	.59248	.40752	1.6878	.73547	1.3597	1.2413	.19442	.80558	40	
	30	.59482	.40518	1.6812	.73996	1.3514	1.2440	.19614	.80386	30	
	40	.59716	.40284	1.6746	.74447	1.3432	1.2467	.19788	.80212	20	
	50	.59949	.40051	1.6681	.74900	1.3351	1.2494	.19962	.80038	10	
37	0	.60181	.39818	1.6616	.75355	1.3270	1.2521	.20136	.79863		53
	10	.60413	.39586	1.6552	.75812	1.3190	1.2549	.20312	.79688	50	
	20	.60645	.39355	1.6489	.76271	1.3111	1.2577	.20488	.79512	40	
	30	.60876	.39124	1.6427	.76733	1.3032	1.2605	.20665	.79335	30	
	40	.61107	.38893	1.6365	.77196	1.2954	1.2633	.20842	.79158	20	
	50	.61337	.38663	1.6303	.77661	1.2876	1.2661	.21020	.78980	10	
38	0	.61566	.38434	1.6243	.78128	1.2799	1.2690	.21199	.78801		52
	10	.61795	.38205	1.6182	.78598	1.2723	1.2719	.21378	.78622	50	
	20	.62023	.37976	1.6123	.79070	1.2647	1.2748	.21558	.78441	40	
	30	.62251	.37748	1.6064	.79543	1.2572	1.2778	.21739	.78261	30	
	40	.62479	.37521	1.6005	.80020	1.2497	1.2807	.21921	.78079	20	
	50	.62706	.37294	1.5947	.80498	1.2423	1.2837	.22103	.77897	10	
39	0	.62932	.37068	1.5890	.80978	1.2349	1.2867	.22285	.77715		51
	10	.63158	.36842	1.5833	.81461	1.2276	1.2898	.22469	.77531	50	
	20	.63383	.36617	1.5777	.81946	1.2203	1.2929	.22653	.77347	40	
	30	.63608	.36392	1.5721	.82434	1.2131	1.2960	.22837	.77162	30	
	40	.63832	.36168	1.5666	.82923	1.2059	1.2991	.23023	.76977	20	
	50	.64056	.35944	1.5611	.83415	1.1988	1.3022	.23209	.76791	10	
40	0	.64279	.35721	1.5557	.83910	1.1917	1.3054	.23395	.76604		50
	10	.64501	.35499	1.5503	.84407	1.1847	1.3086	.23583	.76417	50	
	20	.64723	.35277	1.5450	.84906	1.1778	1.3118	.23771	.76229	40	
	30	.64945	.35055	1.5398	.85408	1.1708	1.3151	.23959	.76041	80	
	40	.65166	.34834	1.5345	.85912	1.1640	1.3184	.24149	.75851	20	
	50	.65386	.34614	1.5294	.86419	1.1571	1.3217	.24338	.75661	10	
41	0	.65606	.34394	1.5242	.86929	1.1504	1.3250	.24529	.75471		49
	10	.65825	.34175	1.5192	.87441	1.1436	1.3284	.24720	.75280	50	
	20	.66044	.33956	1.5141	.87955	1.1369	1.3318	.24912	.75088	40	
	30	.66262	.33738	1.5092	.88472	1.1303	1.3352	.25104	.74895	30	
	40	.66479	.33520	1.5042	.88992	1.1237	1.3386	.25297	.74702	20	
	50	.66697	.33303	1.4993	.89515	1.1171	1.3421	.25491	.74509	10	
42	0	.66913	.33087	1.4945	.90040	1.1106	1.3456	.25685	.74314		48
	10	.67129	.32871	1.4897	.90568	1.1041	1.3492	.25880	.74119	50	
	20	.67344	.32656	1.4849	.91099	1.0977	1.3527	.26076	.73924	40	
	30	.67559	.32441	1.4802	.91633	1.0913	1.3563	.26272	.73728	30	
	40	.67773	.32227	1.4755	.92170	1.0849	1.3600	.26469	.73531	20	
	50	.67987	.32013	1.4709	.92709	1.0786	1.3636	.26666	.73333	10	
43	0	.68200	.31800	1.4663	.93251	1.0724	1.3673	.26865	.73135		47
	10	.68412	.31588	1.4617	.93797	1.0661	1.3710	.27063	.72937	50	
	20	.68624	.31376	1.4572	.94345	1.0599	1.3748	.27263	.72737	40	
	30	.68835	.31164	1.4527	.94896	1.0538	1.3786	.27462	.72537	30	
	40	.69046	.30954	1.4483	.95451	1.0476	1.3824	.27663	.72337	20	
	50	.69256	.30744	1.4439	.96008	1.0416	1.3863	.27864	.72136	10	
44	0	.69466	.30534	1.4395	.96569	1.0355	1.3902	.28066	.71934		46
	10	.69675	.30325	1.4352	.97133	1.0295	1.3941	.28268	.71732	50	
	20	.69883	.30117	1.4310	.97699	1.0235	1.3980	.28471	.71529	40	
	30	.70091	.29909	1.4267	.98270	1.0176	1.4020	.28675	.71325	30	
	40	.70298	.29702	1.4225	.98843	1.0117	1.4060	.28879	.71121	20	
	50	.70505	.29495	1.4183	.99420	1.0058	1.4101	.29084	.70916	10	
45	0	.70711	.29289	1.4142	1.0000	1.0000	1.4142	.29289	.70711		45
		Co-sine	Vers. Sin.	Secant	Co-tang.	Tangent	Cosecant	Vers. Cos.	Sine		

Trigonometrical Functions



Let angle AOF be denoted by C.

OA = radius R.

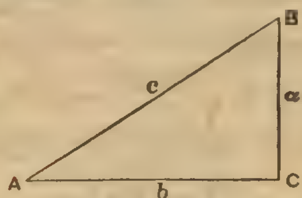
Sine	$C = FG$
Cosine	$C = OG$
Tangent	$C = AI$
Cotangent	$C = DL$
Secant	$C = OI$
Cosecant	$C = OL$
Versed sine	$C = GA$
Coversed sine	$C = DK$

Trigonometrical Equivalents

Sine	$= \sqrt{1 - \text{Cos.}^2}$	Cos.	$= \sqrt{1 - \text{Sine}^2}$
Sine	= Cos. ÷ Cotang.	Cos.	= Sine ÷ Tang.
Tang.	= 1 ÷ Cotang.	Cos.	= Sine × Cotang.
Cosec.	= 1 ÷ Sine.	Tang.	= Sine ÷ Cosine.
Secant	= 1 ÷ Cos.	Cotang.	= Cosine ÷ Sine.
Vers.	= Rad. — Cos.	$(\text{Rad.})^2$	$= \text{Sine}^2 + \text{Cos.}^2$
Covers.	= Rad. — Sine.	$(\text{Secant})^2$	$= \text{Radius}^2 + \text{Tang.}^2$

Cotang. = 1 ÷ Tang.

Right Angled Triangles

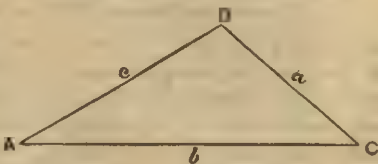


Sin. $A = \frac{a}{c}$ Tang. $A = \frac{a}{b}$ Sec. $A = \frac{c}{b}$

Cos. $A = \frac{b}{c}$ Cot. $A = \frac{b}{a}$ Cosec. $A = \frac{c}{a}$

GIVEN	REQUIRED	FORMULÆ
a, c	A, B, b	$\text{Sin. } A = \frac{a}{c}$; $\text{cos. } B = \frac{a}{c}$; $b = \sqrt{(c+a)(c-a)}$
a, b	A, B, c	$\text{Tang. } A = \frac{a}{b}$; $\text{cot. } B = \frac{a}{b}$; $c = \sqrt{a^2 + b^2}$
A, a	B, b, c	$B = 90° - A$; $b = a \times \text{cot. } A$; $c = \frac{a}{\text{sin. } A}$
A, b	B, a, c	$B = 90° - A$; $a = b \times \text{tang. } A$; $c = \frac{b}{\text{cos. } A}$
A, c	B, a, b	$B = 90° - A$; $a = c \times \text{sin. } A$; $b = c \times \text{cos. } A$

OBLIQUE ANGLED TRIANGLES

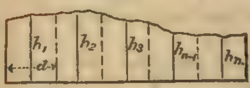


GIVEN	REQUIRED	FORMULÆ
A, B, a	b	$b = a \frac{\text{sin. } B}{\text{sin. } A}$
A, a, b	B	$\text{Sin. } B = \frac{b \text{ sin. } A}{a}$
a, b, C	$A - B$	$\text{Tang. } \frac{1}{2}(A - B) = \frac{(a-b) \text{ tang. } \frac{1}{2}(A+B)}{a+b}$
a, b, c	A	Let $S = \frac{1}{2}(a+b+c)$; $\text{sin. } \frac{1}{2}A = \sqrt{\frac{(s-b)(s-c)}{b \times c}}$; $\text{cos. } \frac{1}{2}A = \sqrt{\frac{s(s-a)}{bc}}$; $\text{tang. } \frac{1}{2}A = \sqrt{\frac{(s-b)(s-c)}{s(s-a)}}$; $\text{sin. } A = \frac{2\sqrt{s(s-a)(s-b)(s-c)}}{bc}$
A, B, C, a	Area	$\text{Area} = \frac{a^2 \text{ sin. } B \text{ sin. } C}{2 \text{ sin. } A}$
A, b, c	Area	$\text{Area} = \frac{1}{2} b \times c \times \text{sin. } A.$
a, b, c	Area	$\text{Area} = \sqrt{s(s-a)(s-b)(s-c)}$ where $s = \frac{1}{2}(a+b+c)$.

MENSURATION

Triangle, Area = base × ½ perpendicular height.
Parallelogram, Area = base × perpendicular height.
Trapezoid, Area = ½ sum of parallel sides × perpendicular height.

Area of an Irregular Plane Surface



Divide the surface into any number of parallel strips of equal widths, "d" take the middle ordinates h_1, h_2, etc.

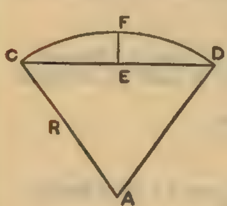
I. $\text{Area} = d \times \Sigma h + \frac{d}{12}(a - h_1) + \frac{d}{12}(b - h_n)$ (Poncelet's rule).

II. $\text{Area} = d \times \Sigma h + \frac{d}{72}(8a + h_2 - 9h_1) + \frac{d}{72}(8b + h^{n-1} - 9h_n)$ (Francke's rule).

III. $\text{Area} = d \times \Sigma h$.
Σ is symbol for sum of.

Circle

Circumference = 3.1416 × diameter.
Length of an arc = diameter × number of degrees in arc × 0.0087266.



Chord of arc $= CD = \sqrt{D^2 - (D - 2h)^2}$ $= 2\sqrt{R^2 - (R - h)^2}$

Chord of ½ Arc $= \frac{1}{2}\sqrt{\overline{CD}^2 + 4h^2} = \sqrt{D \times h}$

$$\text{Diameter} = \frac{\frac{\overline{CD}^2}{4} + h^2}{h}$$

Versed sine $h = \frac{1}{2}\left(D - \sqrt{D^2 - \overline{CD}^2}\right)$ or nearly $\frac{\overline{CD}^2}{8r}$

Area Circle = .7854 (diam.)^2

$$\text{Area Sector } ADFCA = \frac{R}{2} \times \text{arc } DFC = \frac{3.1416 \times R^2 \times \text{angle } DAC \text{ in degrees}}{360}$$

Area Segment $CDFC = \frac{1}{2}\left[\text{arc } DFC \times R - \overline{CD}\,(R - h)\right]$

Sphere

Sphere, Surface $= 12.5664\ R^2 = 3.1416\ D^2$
Sphere, Volume $= 4.189\ R^3$
Spherical Sector, Surface $= 1.5708\ (4h + \overline{CD})$
Spherical Sector, Volume $= 2.0944\ R^2h = 2.0944\ R^2 \times$

$$\left(R \pm \sqrt{R^2 - \frac{\overline{CD}^2}{4}}\right)$$

Spherical Zone, Surface $= 6.2832 \times R \times h =$
$0.7854\ (\overline{CD}^2 + 4\,h^2)$
Spherical Zone, Volume $= 3.1416\ h^2\ (R - \frac{1}{3}\,h) =$

$$3.1416\ h^2 \left(\frac{\overline{CD}^2 + 4\,h^2}{8\,h} - \frac{1}{3}\,h\right)$$

Ellipse

Circumference of an ellipse $= 3.1416 \sqrt{\frac{D^2 + d^2}{2}}$ approximately, where D is major axis and d the minor axis.

Area ellipse $= .7854\ D \times d$.

Ellipsoid surface $= 2.22\,d\ \sqrt{D^2 + d^2}$
" volume $= 0.5231\ D\,d^2$

Parabola

Area of parabola $= \frac{2}{3}$ area of circumscribing rectangle.

Paraboloid volume $= 1.5707 \times$ altitude $\times$ square of radius of base.

Cylinder

Convex surface $= 3.1416 \times$ diam. of base $\times$ altitude.

Entire " $= 3.1416 \times$ diam. of base $\times$ altitude $+ 1.5708 \times$ [diam.^{2}].

Volume $= 0.7854$ diam.$^2 \times$ altitude.

Cone

Convex surface = circumference of base $\times \frac{1}{2}$ slant height.

Volume = area of base $\times \frac{1}{3}$ altitude.

Frustrum of Right Cone

Convex surface $-$ 1.5708 $\times$ slant height of frustrum $\times$ sum of diam. of bases.

Volume $-$ 0.2618 $\times$ altitude $\times$ [square of diam. of lower base + square of diam. of upper base + product of 2 diameters.]

Prism

Convex surface = perimeter of base × altitude.
Volume = area of base × altitude.

Pyramid

Convex surface regular pyramid = perimeter of base × $\frac{1}{2}$ slant height.
Volume = area base × $\frac{1}{3}$ altitude.

Frustrum of a Regular Pyramid

Convex surface = $\frac{1}{2}$ slant height × sum of perimeters of bases.
Volume = $\frac{1}{3}$ altitude × [sum of areas of 2 bases + square root of product of the 2 bases].

USEFUL INFORMATION.

To find circumference of a circle multiply diameter by 3.1416.

To find diameter of a circle multiply circumference by .3183.

To find area of a circle multiply square of diameter by .7854.

To find surface of a ball multiply square of diameter by 3.1416.

To find side of an equal square multiply diameter by .8862.

To find cubic inches in a ball multiply cube of diameter by .5236.

Doubling the diameter of a pipe increases its capacity four times.

A gallon of water (U. S. standard) weighs $8\frac{1}{3}$ lbs. and contains 231 cubic inches.

A cubic foot of water contains 7.48 gallons, 1728 cubic inches, and weighs 62.4 lbs.

To find the pressure in pounds per square inch of a column of water multiply the height of the column in feet by .434.

A standard horse power: The evaporation of 30 lbs. of water per hour from a feed-water temperature of 100° F. into steam at 70 lbs. gauge pressure. One horse power

is the power required to raise 33,000 lbs. one foot in one minute.

Equals 33,000 foot-pounds per minute
" 1,980,000 " " hour

See page 59.

To find the horse power of an engine multiply the piston speed in feet per minute by the area of the piston in square inches and by the mean effective pressure, then divide by 33,000.

Each nominal horse power in boilers requires one cubic foot of water per hour.

In calculating horse power of tubular boilers, consider 12 square feet of heating surface equal to one nominal horse power.

To find capacity of tanks any size; given dimensions of a cylinder in inches, to find its capacity in U. S. gallons: Square the diameter, multiply by the length and by .0034.

To approximately ascertain heating surface in tubular boilers multiply ⅔ the circumference of boiler by length of boiler in inches and add to it the area of all the tubes.

When designing boilers the T. S. is specified, the factor of safety, diameter and pressure per square inch are decided upon, and the only quantities remaining unknown are the thickness and the efficiency of the joint.

Let P = pressure of steam in pounds per square inch.
T = thickness of plate in shell.
E = efficiency of joints in shell.
D = diameter of shell.
S_1 = ultimate strength of material.
F = factor of safety.

Solving the equation $\frac{D \times P \times F}{2\,S_1} = T \times E$

$$\text{or } \frac{D \times P \times F}{2\,S_1 \times E} = T$$

Pressure allowable for concaved heads of boilers: Multiply the pressure per square inch allowable for bumped heads attached to boilers or drums convexly by the constant .6, and the product will give the pressure per square inch allowable in concaved heads.—*U. S. Gov. Rule II, Par. 12.*

To find the amount of air that can be produced by different size air cylinders: Find the area of the cylinder and multiply that by the stroke; then multiply result by 2 if it is a Straight Line Compressor; by 4 if a Duplex Compressor; or by 2 if Compound Duplex Compressor. Divide this result by 1728, which will give amount of air per stroke and then multiply by number of strokes per minute.

A System

for

Economically Transmitting

by

Telegraph

Messages Relating to and Specifications for

Steel Plates

CODE

QUESTIONS AND ANSWERS

Allegheny	—At what price will you furnish . . . tons . . . steel for immediate delivery?
Appomattox	—At what price will you furnish . . . tons . . . steel for delivery in . . . days?
Big Sandy	—How soon can you deliver . . . tons . . steel?
Chemung	—At what price and how soon will you deliver . . . tons . . . steel?
Congaree	—At what price will you deliver at . . . ., . . . tons . . . steel?
Genesee	—What is the lowest contract rate of freight you can obtain by cheapest route to . . . .?
Housatonic	—What is the lowest contract rate of freight you can obtain by fast freight to . . .?
Juniata	—What is the lowest rate by express per 100 pounds to . . .?
Kanawha	—When will our (my) order dated . . . be shipped?
Kankakee	—What discount from price will you allow for prompt cash on receipt of invoice and bill of lading?
Lehigh	—What discount from price will you allow for prompt cash on receipt of goods?
Merrimac	—What are your best terms (longest time) you will allow us on our orders?
Moselle	—Did you receive our letter of . . .?
Murray	—Did you receive our telegram of . . .?
Malheur	—By what route did you ship?

Marias	—When did you ship?
Machias	—Has there been any change in price?
Murchison	—Is price quoted net, or list, subject to a discount?
Magdalena	—Can you substitute?
Meta	—Have you sold?
Mamore	—Is the order still in force?
Maderia	—Have you remitted?
Mezene	—How shall we draw?
Marcus	—Shall we draw at sight?
Maros	—Have you drawn?
Meinam	—How have you drawn?
Main	—How much did you draw for?
Maravia	—Have you anything new to report?
Maroni	—Is there anything further in this locality that requires attention?
Missouri	—Where will a telegram reach you on . . ?
Mackenzie	—Address telegram for me to care of . . .
Madawaska	—Telegraph at once. Will wait here for reply.
Mohawk	—Make for us immediately and ship per first steamer.
Monongahela	—Make for us immediately and ship per fast freight.
Maumee	—Make for us immediately and ship per express.
Miami	—Make for us immediately and ship per rail.
Mobile	—Make for us immediately and ship per rail and lake.
Niagara	—Duplicate our entire order of date . . . instant.
Ocmulgee	—Duplicate entire revised order of date . . . . instant.

Piscataqua —Have shipment of our order of date . . . . instant, wired through to us. We are in pressing need of the stock.

Passaic —Send telegraphic tracer after your shipment to us of date . . . . . . instant. The stock has not arrived.

Potomac —Shipment dated . . . . , partly arrived, have tracer sent after . . . . missing plates.

Penobscot — . . . . pounds ready on all your open orders; cannot promise definitely when we can complete a carload. Shall we ship what is ready?

Pecos — . . . . pounds ready, but on account lengths will require two cars; cannot promise definitely when double carload will be ready. Shall we ship everything ready?

Piquinto — . . . . pounds ready, but on account of lengths will take double carload. Will have sufficient tonnage ready by (or in) . . . . . .

Panuco —All material due on your order is ready, but is insufficient for carload. Shall we ship or will you add enough for carload?

Patuca —Ready waiting carload. Shall we ship local?

Purus —Ship what you have ready.

Plague —Ship what you have ready, and balance as soon as possible.

Plaint —Minimum tensile strength to be 60,000 pounds per square inch.

Played —Minimum tensile strength to be 65,000 pounds per square inch.

Pleader	—Minimum tensile strength to be 50,000 pounds per square inch.
Pledged	—Order is being executed and cannot be cancelled.
Plaintly	—Too late to make any alterations in order now.
Plinth	—The alterations in order have been (or will be) made.
Plodder	—See letter.
Popgun	—If not satisfactory, telegraph at once.
Parana	—Reply by telegraph at our expense.
Panaro	—We have none in stock, but can make and ship.
Powder	—For immediate acceptance.
Pilcomayo	—Reply immediately by wire, as we cannot permit the matter to remain open.
Pollux	—We will hold offer open until . . . . .
Polite	—We hereby withdraw all quotations.
Poems	—We cannot hold offer open later than . . . .
Pamlico	—Telegram recalling offer received too late—had already closed.
Pamunkey	—Your telegram received, but as we (or I) cannot reply to-day, we (or I) shall consider offer good for reply to-morrow unless you telegraph to-day withdrawing it.
Paria	—Received your telegram and have closed the business.
Pataha	—Answer by telephone.
Parwe	—Will call you up by telephone at . . . .
Patapsco	—Do you consider it advisable?
Poacher	—Your telegram has become unintelligible in transmission; please repeat.
Pechora	—The telegram ought to read . . . .

Palouse —Explanation of doubtful telegram by mail.

Plural —Freight, by rail, in carloads, per 100 pounds is . . . .

Plumes —Freight, by rail, in less than carloads is . . . .

Plumber —See our letter of . . . .

Plumage —See our telegram of . . . .

Raritan —Substitute . . . . plates . . . . . . for . . . . plates . . . . in our order of date . . . . instant.

Rappahannock—Suspend work on our order of date . . . . instant.

Roanoke —Suspend work on our order of date . . . . . . until receipt of our revised specification.

Saranac —Suspend work on our order of date . . . . . instant, until receipt of revised specification mailed to you this day.

Saguenay —Wire quickly lowest price and earliest delivery the following plates . . . .

Savannah —Data not sufficient. Must have drawings or sketches before we can bid.

Santee — . . . . are in the market for . . . . Can secure preference at . . . . Will you authorize us to take the order? Answer.

Saskatchewan—Your telegram received.

Saluda —Your letter received.

Sable —Upon receipt of this letter advise immediately by wire or phone.

Sacondaga —How soon after receipt of order can you ship?

Sacramento —We can ship promptly if our inspection is accepted.

Sabine	—We can ship at once.
Saco	—We can ship to-morrow, if ordered at once.
Slave	—We can ship in two days after order, if ordered at once.
Skeena	—We can ship this week, if ordered at once.
Souris	—We can ship in one week after order, if ordered at once.
Shenandoah	—We can ship in a week or ten days after order, if ordered at once.
Staunton	—We can ship in ten days after order, if ordered at once.
Susquehanna	—We can ship in two to three weeks after order, if ordered at once.
Surinam	—We can ship in three to four weeks, if ordered at once.
Tallapoosa	—Cannot promise definite time delivery. Will do the very best we can.

NOTE.—("If not unexpectedly delayed for reasons beyond our control,")—should be understood as following all the above promises to ship in a specified time.

Tensas	—We shipped your order on the . . . .
Thames	—We have shipped.
Tombigbee	—We cannot ship at present for want of cars.
Tigris	—Pounds per square foot.
Tiber	—We cannot sell at the price you offer.
Trinity	—We cannot shade the price quoted.
Tugaloo	—The price quoted is net F. O. B. Coatesville.
Ural	—The price quoted is subject to freight allowance to your city.

Uruguay	—To meet requirements of latest Standard Specifications of Association of American Steel Manufacturers for Soft Steel.
Vistritza	—To meet requirements of latest Standard Specifications of Association of American Steel Manufacturers for Medium Steel.
Vermejo	—To meet requirements of latest Standard Specifications of Association of American Steel Manufacturers for Flange or Boiler Steel.
Vilaine	—To meet requirements of latest Standard Specifications of Association of American Steel Manufacturers for Fire-box Steel.
Verdigris	—The minimum and maximum tensile strength to be 55,000 to 60,000 pounds per square inch.
Ventuari	—Elongation to be 25% in 8 inches.
Vistula	—Reduction of area 50%.
Volga	—Furnish copy of mill test of at least two plates.
Wabash	—Leave coupons on all the Rectangular plates.
Weser	—All plates for marine work, and subject to Government inspection.
Zambesi	—This boiler work will be subject to Hartford inspection.

Number of Plates Required

1 Aback	30 Affirm
2 Abaft	31 Afflict
3 Abase	32 Afford
4 Abated	33 Affray
5 Abbot	34 Afresh
6 Abide	35 Again
7 Abject	36 Ahead
8 Abroad	37 Ahoy
9 Abound	38 Aim
10 Abrupt	39 Aisle
11 Absent	40 Akin
12 Absorb	41 Alarm
13 Abused	42 Alas
14 Accuse	43 Albino
15 Acorn	44 Album
16 Acquit	45 Alder
17 Across	46 Alert
18 Acted	47 Alike
19 Actor	48 Allow
20 Acute	49 Allude
21 Adapt	50 Aloft
22 Adhere	51 Aloud
23 Adjoin	52 Alpaca
24 Admit	53 Alpine
25 Adore	54 Amber
26 Advent	55 Amid
27 Adverb	56 Amity
28 Advise	57 Amuse
29 Affair	58 Anchor

NUMBER OF PLATES REQUIRED—*Concluded*

59	Anew	84	Arson
60	Angle	85	Artery
61	Angry	86	Ascend
62	Annoy	87	Aslant
63	Anthem	88	Asleep
64	Anthill	89	Assail
65	Anvil	90	Assent
66	Apace	91	Assign
67	Apart	92	Assume
68	Apathy	93	Astray
69	Appetite	94	Asylum
70	Appear	95	Attain
71	Apron	96	Attend
72	Arab	97	Auburn
73	Arch	98	Aurora
74	Arctic	99	Author
75	Ardent	100	Avast
76	Argosy	200	Averse
77	Aright	300	Avidious
78	Armlet	400	Avarice
79	Armory	500	Avenged
80	Armies	600	Avenue
81	Arouse	700	Avouch
82	Arrange	800	Avowal
83	Arrest	900	Awake

1000 Awning

QUALITY REQUIRED

STEEL PLATES

SORGHUM	Tank
EXOTIC	Flange
EVERGREEN	Fire Box
LICHEN	Marine
EXTRA	Extra Locomotive Fire Box

THICKNESS

OF

STEEL PLATES

$\frac{1}{8}$	Antelope
No. 10	Bear
No. 9	Buffalo
No. 8	Deer
No. 7	Dog
$\frac{3}{16}$	Elk
No. 6	Elephant
No. 5	Fox
No. 4	Goat
$\frac{1}{4}$	Horse
No. 3	Hyena
No. 2	Jackal
No. 1	Kangaroo
$\frac{5}{16}$	Lion
$\frac{3}{8}$	Lynx
$\frac{7}{16}$	Leopard
$\frac{1}{2}$	Merino
$\frac{9}{16}$	Opossum
$\frac{5}{8}$	Otter
$\frac{11}{16}$	Panther
$\frac{3}{4}$	Raccoon
$\frac{13}{16}$	Rabbit
$\frac{7}{8}$	Sheep
$\frac{15}{16}$	Tiger
1	Tapir
$1\frac{1}{8}$	Turtle
$1\frac{1}{4}$	Whale
$1\frac{3}{8}$	Walrus
$1\frac{1}{2}$	Wolf
$1\frac{5}{8}$	Weasel
$1\frac{3}{4}$	Wren

Widths of Plates

The following words will answer for transmitting fractions of an inch:

1-4	Came
1-2	Saw
3-4	Conquered

In specifying fractions of an inch, above should be used IN ADDITION to the other word signifying width, length, or diameter wanted, as the case may be.

6	Babble	29	Brains	52	Cinder
7	Badly	30	Break	53	Clamor
8	Balmy	31	Cabal	54	Clarify
9	Bandit	32	Caddy	55	Clergy
10	Bantam	33	Cake	56	Cloak
11	Bargains	34	Calendar	57	Coaches
12	Basely	35	Calker	58	Coffee
13	Bathe	36	Calumny	59	Comet
14	Bayard	37	Camlet	60	Cooler
15	Beast	38	Canary	61	Dabble
16	Become	39	Candor	62	Damage
17	Beeves	40	Canopy	63	Dapper
18	Begin	41	Capital	64	Dative
19	Behind	42	Carbon	65	Dandle
20	Belong	43	Caress	66	Dazzle
21	Bestir	44	Carry	67	Debase
22	Beyond	45	Casket	68	Defile
23	Birch	46	Caveat	69	Decay
24	Bleeds	47	Cellar	70	Deepen
25	Bluff	48	Chance	71	Delight
26	Bobbin	49	Cheek	72	Demon
27	Booked	50	Chisel	73	Dialect
28	Bound	51	Chorus	74	Deploy

WIDTHS OF PLATES—*Concluded*

75	**Diamond**	95	**Dogged**	115	**Don**
76	**Dignity**	96	**Doggedness**	116	**Donkey**
77	**Detach**	97	**Dogma**	117	**Donor**
78	**Device**	98	**Dogmatic**	118	**Doom**
79	**Diadem**	99	**Dogmatizer**	119	**Doris**
80	**Disarm**	100	**Doily**	120	**Dormant**
81	**Dismay**	101	**Doings**	121	**Dory**
82	**Dodge**	102	**Dole**	122	**Dotage**
83	**Dragoon**	103	**Doleful**	123	**Dough**
84	**Dowager**	104	**Dolesome**	124	**Douse**
85	**Docible**	105	**Doll**	125	**Dove**
86	**Docility**	106	**Dollar**	126	**Dowel**
87	**Dock**	107	**Dolorous**	127	**Dower**
88	**Doctor**	108	**Dolt**	128	**Downy**
89	**Doctress**	109	**Domain**	129	**Drake**
90	**Doctrinal**	110	**Dome**	130	**Drama**
91	**Document**	111	**Domestic**	131	**Draw**
92	**Dodo**	112	**Domicile**	132	**Dream**
93	**Doer**	113	**Domineer**		
94	**Doff**	114	**Dominion**		

Lengths of Plates

The following words will answer for transmitting fractions of an inch:

1-4	Came
1-2	Saw
3-4	Conquered

In specifying fractions of an inch, above should be used IN ADDITION to the other word signifying width, length, or diameter wanted, as the case may be.

12	Eager
13	Earldom
14	Ear-ring
15	Easel
16	Easterly
17	Eaves
18	Echelon
19	Ecstasy
20	Edging
21	Edify
22	Educate
23	Efface
24	Egotism
25	Eject
26	Elated
27	Elder
28	Elegant
29	Elfin
30	Eligible
31	Eloped
32	Emanate
33	Ember
34	Embrace
35	Emigrant
36	Empanel
37	Empty
38	Enamel
39	Endear
40	Endow
41	Enemy
42	Engineer
43	Enigma
44	Enlist
45	Enormity
46	Ensign
47	Enter
48	Entreat
49	Enviable
50	Epilogue
51	Equality
52	Equity
53	Errand

LENGTHS OF PLATES—Continued

54	Eschew	89	Flyer
55	Essay	90	Fodder
56	Etching	91	Foliage
57	Ethics	92	Fooled
58	Eunuch	93	Forded
59	Evening	94	Foster
60	Evermore	95	Fraud
61	Exact	96	Frenzy
62	Exceed	97	Frisky
63	Excuse	98	Frozen
64	Exhale	99	Fugue
65	Exhume	100	Furze
66	Fable	101	Gable
67	Faceless	102	Gaiety
68	Factor	103	Galaxy
69	Fagot	104	Gambler
70	Faith	105	Gaoler
71	Falsette	106	Garret
72	Famish	107	Gauged
73	Fangle	108	Gelder
74	Fastened	109	Gentle
75	Faucet	110	Gilder
76	Feline	111	Girths
77	Fence	112	Glance
78	Fetched	113	Gloated
79	Fickle	114	Gloves
80	Figure	115	Gnome
81	Finger	116	Goodly
82	Fiscal	117	Gospel
83	Flabby	118	Gouty
84	Flashy	119	Graded
85	Flaxen	120	Grassy
86	Flighty	121	Habit
87	Float	122	Hamlet
88	Flower	123	Hangeth

LENGTHS OF PLATES—*Continued*

124	Harem
125	Hasty
126	Haven
127	Heaper
128	Heave
129	Heeded
130	Height
131	Herald
132	Hereof
133	Hewed
134	Hiatus
135	Hither
136	Hobby
137	Honest
138	Hotbed
139	Hugged
140	Hunter
141	Iceberg
142	Idolater
143	Illness
144	Imitate
145	Impart
146	Impel
147	Impugn
148	Indian
149	Influx
150	Inmate
151	Labial
152	Ladder
153	Lagoon
154	Languid
155	Larger
156	Lastly
157	Lateral
158	Lattice
159	Lawsuit
160	Lazily
161	League
162	Legacy
163	Lenten
164	Levant
165	Lexicon
166	Liberty
167	Lifted
168	Ligneous
169	Lilies
170	Linden
171	Lingo
172	Lintel
173	Listen
174	Litigant
175	Livelong
176	Loadstar
177	Lobelia
178	Lockjaw
179	Lofty
180	Longer
181	Loudly
182	Lowest
183	Lucent
184	Limber
185	Lunar
186	Macaw
187	Madman
188	Magnet
189	Majesty
190	Malady
191	Manful
192	Mansard
193	Manure

LENGTHS OF PLATES—Continued

194 Marine
195 Martyr
196 Master
197 Maugre
198 Meadow
199 Medal
200 Meeky
201 Memoir
202 Mentor
203 Merged
204 Merman
205 Method
206 Mewler
207 Midway
208 Milker
209 Mince
210 Minor
211 Mirth
212 Mislay
213 Mizzen
214 Modify
215 Moisten
216 Moody
217 Moral
218 Mortar
219 Mouser
220 Muffin
221 Nabob
222 Nailer
223 Napkin
224 Nation
225 Nausea
226 Nearly
227 Necklace
228 Negro
229 Nervous
230 Nettle
231 Newsboy
232 Nickname
233 Nipper
234 Noddle
235 Noodle
236 Oaken
237 Oatcake
238 Obituary
239 Oblong
240 Obtain
241 Obviate
242 Ocean
243 Ocular
244 Odious
245 Offence
246 Ogled
247 Ointment
248 Omega
249 Oozing
250 Oppose
251 Pacers
252 Packing
253 Pageant
254 Paladin
255 Palfrey
256 Pallor
257 Paltry
258 Pandora
259 Panorama
260 Pantry
261 Parabola
262 Paragon
263 Parish

LENGTHS OF PLATES—Continued

264	Parody	299	Pomade
265	Parrot	300	Pompous
266	Partly	301	Poach
267	Passion	302	Pock
268	Pathos	303	Pod
269	Pavement	304	Poesy
270	Peanut	305	Poetess
271	Pectoral	306	Poetic
272	Pedantry	307	Poetical
273	Pedlar	308	Poetry
274	Pegged	309	Poignant
275	Pelisse	310	Point
276	Peltry	311	Polemical
277	Pendulum	312	Pointed
278	Penury	313	Pointer
279	Perch	314	Pointless
280	Perilous	315	Poise
281	Perked	316	Poke
282	Persist	317	Poker
283	Petals	318	Polarity
284	Petulant	319	Polarize
285	Phantom	320	Polary
286	Phrases	321	Polemic
287	Picketed	322	Police
288	Pigeon	323	Polish
289	Pilfer	324	Politic
290	Pinnace	325	Political
291	Pipkin	326	Polity
292	Pistol	327	Polka
293	Places	328	Poll
294	Planet	329	Pollard
295	Plenty	330	Pollen
296	Plucky	331	Pollock
297	Plunged	332	Pollute
298	Poison	333	Pollution

LENGTHS OF PLATES—*Continued*

334	Poltroon	369	Port
335	Polyglot	370	Portable
336	Polygon	371	Portage
337	Polygraph	372	Portal
338	Polyp	373	Portico
339	Pomace	374	Portion
340	Pony	375	Portly
341	Pomatum	376	Portrait
342	Pommel	377	Portray
343	Pomp	378	Pose
344	Pond	379	Position
345	Ponder	380	Positive
346	Pongee	381	Possess
347	Poniard	382	Possession
348	Pontiff	383	Posset
349	Pontoon	384	Possible
350	Poodle	385	Post
351	Poor	386	Postage
352	Popery	387	Postal
353	Popish	388	Postboy
354	Poppy	389	Posterity
355	Populace	390	Postery
356	Populate	391	Postman
357	Populousness	392	Posture
358	Porphyry	393	Postulate
359	Porcelain	394	Posy
360	Porch	395	Pot
361	Porcine	396	Potable
362	Pore	397	Potash
363	Poriness	398	Potation
364	Pork	399	Potato
365	Porker	400	Potency
366	Porosity	401	Pother
367	Porridge	402	Potion
368	Porringer	403	Pottage

LENGTHS OF PLATES—Concluded

404	**Potter**	438	**Preen**
405	**Pouch**	439	**Preface**
406	**Poulterer**	440	**Prefix**
407	**Poultice**	441	**Pregnant**
408	**Poultry**	442	**Prehensile**
409	**Pounce**	443	**Prejudice**
410	**Pound**	444	**Prelacy**
411	**Pounder**	445	**Prelatism**
412	**Pour**	446	**Prelatic**
413	**Pout**	447	**Preliminary**
414	**Poverty**	448	**Premier**
415	**Power**	449	**Premise**
416	**Powerful**	450	**Premium**
417	**Practical**	455	**Prepare**
418	**Prairie**	460	**Prepense**
419	**Praise**	465	**Presage**
420	**Prance**	470	**Prescribe**
421	**Prank**	475	**Presence**
422	**Prattle**	480	**Preserve**
423	**Prawn**	485	**Preside**
424	**Prayer**	490	**Press**
425	**Prebend**	495	**Pressure**
426	**Precede**	500	**Prestige**
427	**Precedent**	510	**Presto**
428	**Precept**	520	**Presume**
429	**Precious**	530	**Pretend**
430	**Precipice**	540	**Pretext**
431	**Precipitant**	550	**Pretty**
432	**Precise**	560	**Prevail**
433	**Precision**	570	**Prey**
434	**Predial**	580	**Priest**
435	**Predicate**	590	**Prime**
436	**Predict**	600	**Prodigy**
437	**Predominate**		

For longer sizes, use two words, thus:
497″ = **Premium, Enter**

Heads—in Diameter

The following words will answer for transmitting fractions of an inch:

1-4	Came
1-2	Saw
3-4	Conquered

In specifying fractions of an inch, above should be used IN ADDITION to the other word signifying width, length, or diameter wanted, as the case may be.

12	Rabbits
13	Radishes
14	Raging
15	Raisin
16	Ramify
17	Rankle
18	Rapier
19	Rarest
20	Rasper
21	Rational
22	Ravish
23	Readily
24	Reaped
25	Rebel
26	Reckless
27	Recur
28	Reflector
29	Reflow
30	Refund
31	Regal
32	Regent
33	Regret
34	Reigning
35	Relax
36	Relief
37	Relying
38	Remark
39	Remind
40	Remove
41	Renew
42	Renown
43	Rents
44	Repass
45	Repeal
46	Reporter
47	Repute
48	Rescind
49	Reseated
50	Resident
51	Resort
52	Retail
53	Retina
54	Retort
55	Reveals
56	Reviews
57	Revoke
58	Reward
59	Rhyme
60	Riband
61	Richer

HEADS—IN DIAMETER—*Concluded*

62	Riddle	98	Rustic
63	Riders	99	Rustle
64	Riding	100	Ruthless
65	Rifle	101	Rub
66	Rigger	102	Rubber
67	Ringlead	103	Rubescent
68	Ripely	104	Rubied
69	Ripened	105	Ruck
70	Risen	106	Ructation
71	Risking	107	Ruffian
72	Rivalry	108	Rufous
73	Roamer	109	Rugged
74	Roasts	110	Ruggedness
75	Robin	111	Rugose
76	Rocket	112	Rulable
77	Rogue	113	Rule
78	Romish	114	Rum
79	Roofed	115	Ruminant
80	Roosts	116	Rummage
81	Rosary	117	Rump
82	Rotation	118	Rumple
83	Rotten	119	Runagate
84	Rouged	120	Rundle
85	Rousing	121	Rung
86	Royals	122	Runt
87	Rubric	123	Ruse
88	Ruddiest	124	Rusk
89	Rudely	125	Russet
90	Rueful	126	Runner
91	Ruined	127	Rust
92	Ruling	128	Rutabaga
93	Rumbled	129	Rutty
94	Rupee	130	Rusticate
95	Ruralist	131	Rumpus
96	Rushing	132	Rumor
97	Russian		

CONCERNING FLANGED HEADS

Heads to be flanged to sizes given, which are outside diameters when finished

Depth of flange over all to be $3\frac{1}{2}$ inches,	. **Beech**
Depth of flange over all to be 4 inches,	. **Oak**
Depth of flange over all to be $4\frac{1}{2}$ inches,	. **Maple**
Depth of flange over all to be 5 inches,	. **Poplar**
Depth of flange over all to be $5\frac{1}{2}$ inches,	. **Buttonwood**
Depth of flange over all to be 6 inches,	. **Mahogany**

Usual radii for varying sizes of heads are as follows:

12 inches to 24 inches flanged heads = $\frac{1}{2}$ inch

24 inches to 42 inches flanged heads = 1 inch

42 inches to 66 inches flanged heads = $1\frac{1}{4}$ to $1\frac{1}{2}$ inches

66 inches to 120 inches flanged heads = 2 to $2\frac{1}{2}$ inches

Inside radius of flange (sharp as possible),	**Cypress**
Inside radius of flange $\frac{1}{2}$ inch, ...	**Spruce**
Inside radius of flange $\frac{3}{4}$ inch, ...	**Locust**
Inside radius of flange 1 inch, ...	**Larch**
Inside radius of flange $1\frac{1}{4}$ inches, ...	**Linden**
Inside radius of flange $1\frac{1}{2}$ inches, ...	**Palmetto**
Inside radius of flange 2 inches, ...	**Sycamore**
Inside radius of flange $2\frac{1}{2}$ inches, ...	**Banyan**
Inside radius of flange 3 inches, ...	**Juniper**

DECIMALS - 191.
GAS PIPE - 136

$ .00